Injury Control in Initial Entry Training

Dr. Joseph Knapik
DSN584-1328
joseph.knapik@apg.amedd.army.mil

Directorate of Epidemiology and Disease Surveillance
Army Center For Health Promotion & Preventive Medicine
Aberdeen Proving Ground, MD 21010

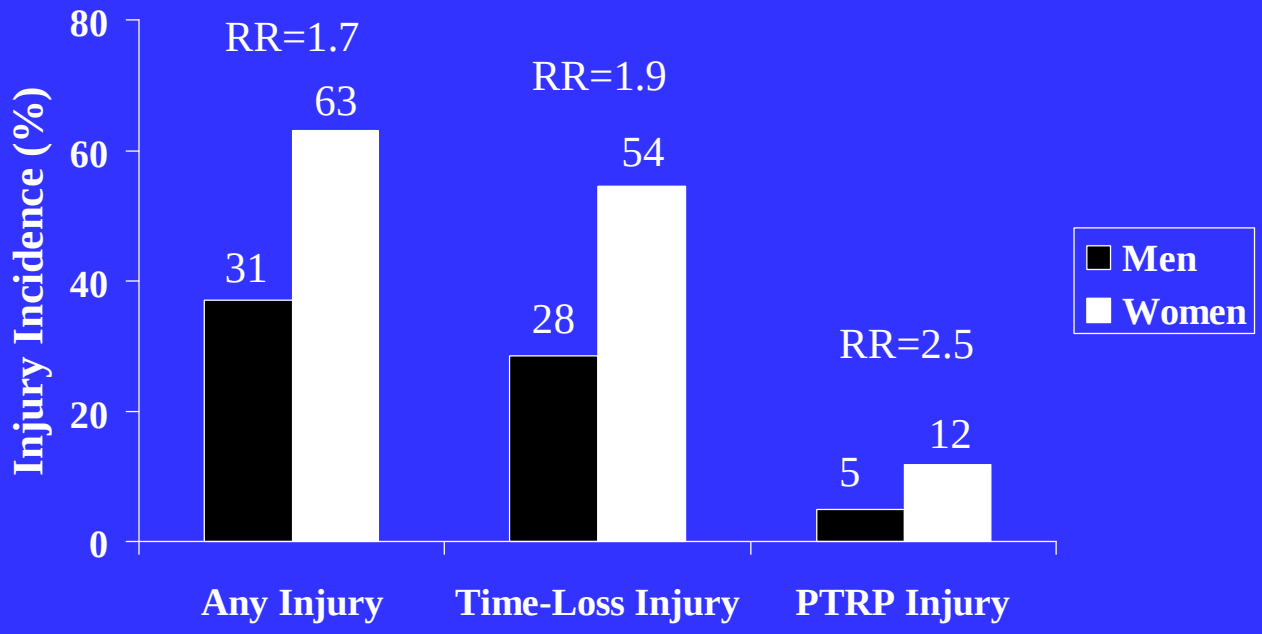
Key Steps in the Injury Control Process

- Surveillance (document problem and size)
- Research (identify cause and risk factors for injuries)
- Intervention (what works to prevent injuries and who needs to know)
- Program Implementation (action based on research and intervention trials)
- Program Monitoring (effectiveness of injury prevention strategy)

Injury Incidence Among Men and Women in Basic Combat Training

Study	BCT Year	Training Post	Men		Women	
			Incidence (%)	Rate (cases/ 100/mo)	Incidence (%)	Rate (cases/ 100/mo)
Kowal (1980)	1978	Ft Jackson	26	13	54	27
Bensel (1983)	1982	Ft Jackson	23	12	42	21
Jones (1993)	1984	Ft Jackson	28	14	50	25
Bell (1996)	1988	Ft Jackson	27	14	57	29
Wstphl (1995)	1994	Ft Jackson	-	-	67	34
Jones (1996)	1996	Ft L. Wood	40	20	64	32
Knapik (1999)	1998	Ft Jackson	31	16	58	29

Injury Incidence of Men and Women by Seriousness of Injury (Ft Jackson 1998)



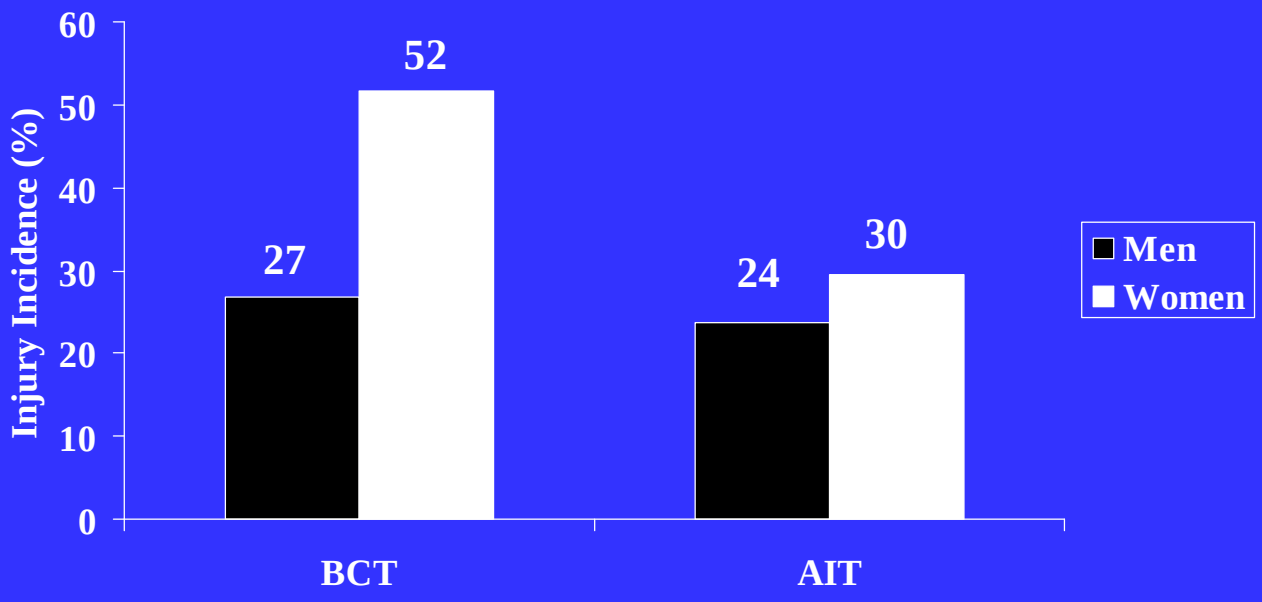
Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Relative Rate of Injury and Illness Among US Army Trainees and Infantry Soldiers

Category	Sample	Injury Rate (n/100 soldier-months)	Illness Rate (n/100 soldier-months)	Rate Ratio (Inj/Ill)
One or More Sick Call Visits	Male Trainees	19.3	19.3	1.0
	Female Trainees	32.7	27.5	1.2
	Infantry	12.8	12.0	1.1
Limited Duty Days	Male Trainees	110	21	5.2
	Female Trainees	266	32	8.3
	Infantry	113	11	10.3

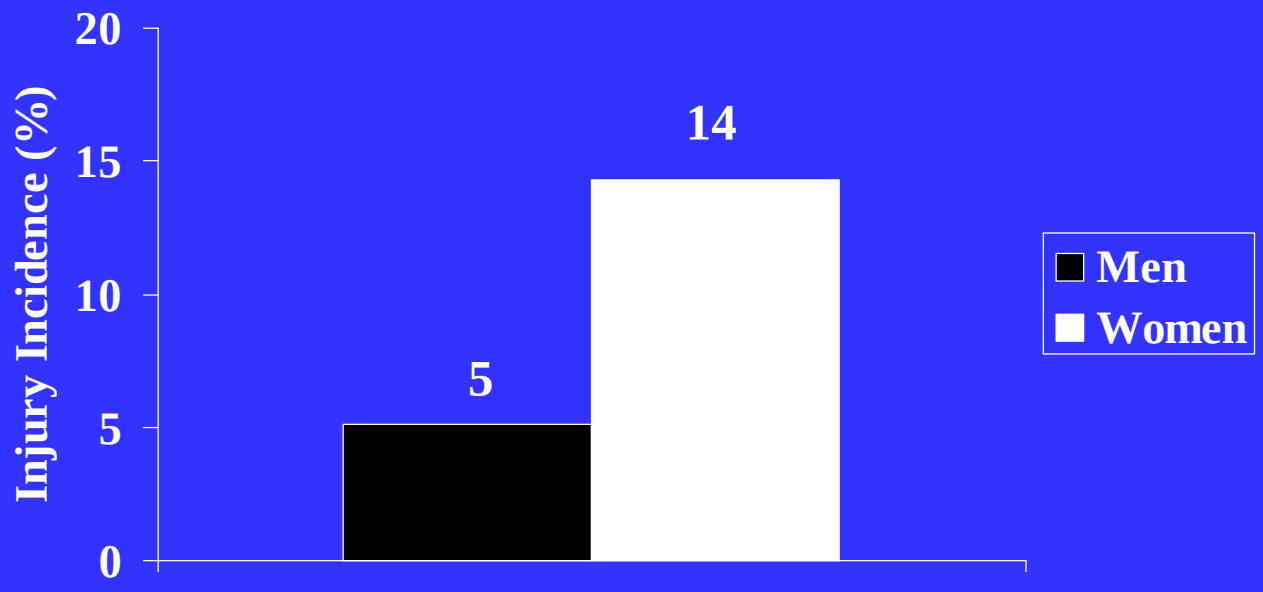
Ft Jackson, Summer, 1998; Ft Drum, 1989

Injury Incidence Among Male and Female Medics



N=438 Men, 287 Women (Ft Sam Houston, TX)
BCT: RR(women/men)=1.9 (95%CI=1.6-2.3), p<0.01
AIT: RR(women/men)=1.2 (95% CI=1.0-1.6), p=0.08
Henderson, Milit Med, In Press

Proportion of Soldiers Entering Medic AIT (91B) with Documented Injuries From BCT



N=583 Men, 300 Women (Ft Sam Houston, TX 1997)
Henderson, Unpublished Data

Key Steps in the Injury Control Process

- Surveillance (document problem and size)
- Research (identify cause and risk factors for injuries)
- Intervention (what works to prevent injuries and who needs to know)
- Program Implementation (action based on research and intervention trials)
- Program Monitoring (effectiveness of injury prevention strategy)

Risk Factors for Injuries

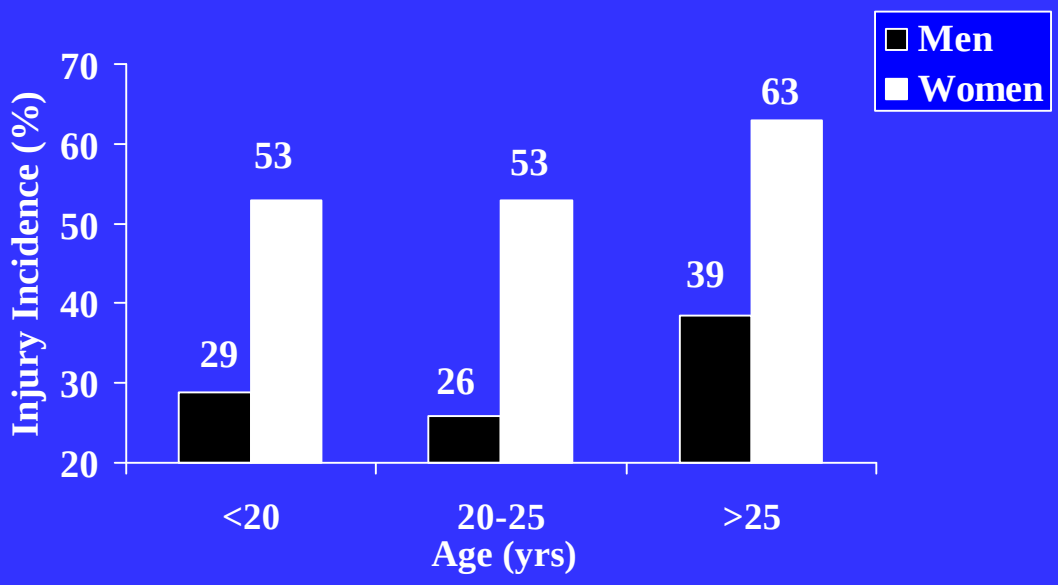
Nonmodifiable

- Female gender
- Older age
- Anatomy
  - Foot arch height
  - Knocked kneed

Modifiable

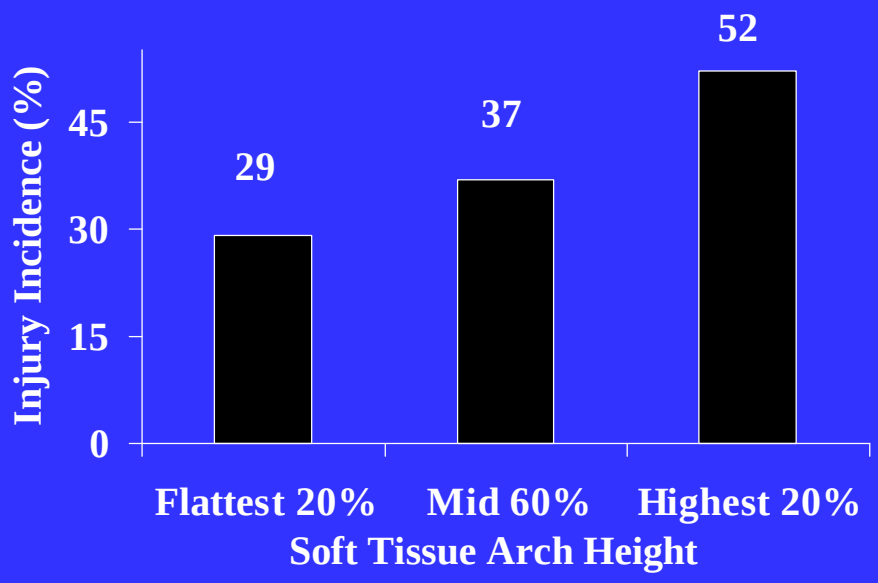
- Physical inactivity
- Low physical fitness
- High and low flexibility
- Cigarette smoking
- Long run mileage
- Old running shoes
- Summer season

Association of Age with Time-Loss Injury in BCT



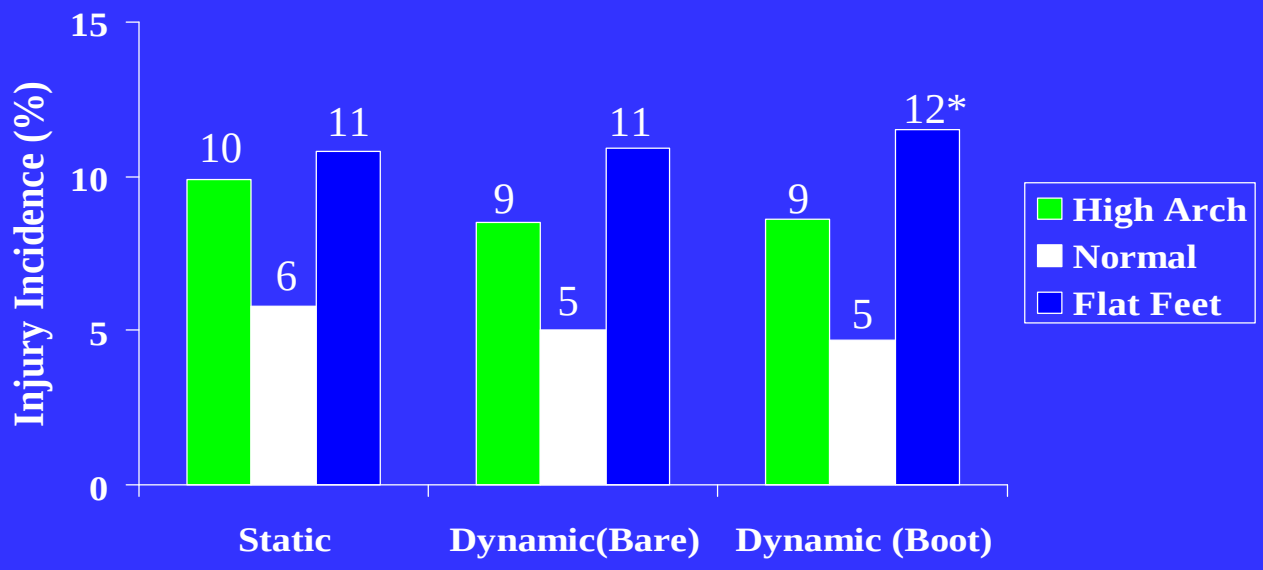
N=729 Men,449 Women; Risk Ratio(>25/<20): Men=1.3, Women=1.2
p-value: Men=0.06, Women=0.07
Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Association of Foot Arch Height with Lower Extremity Injury in Infantry OSUT



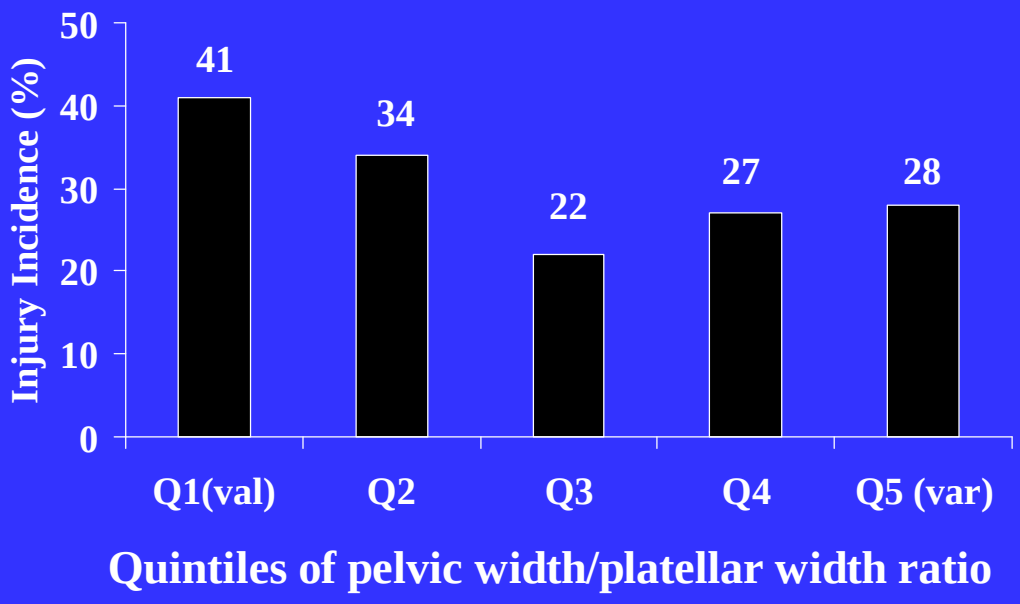
N=246 Men; Risk Ratio(Highest/Flattest)=1.8
Cowan, Arch Fam Med 2:773, 1993 (Ft Benning, 1989)

Association of Foot Type and Stress Fractures in SEAL Candidates



Kaufman, Am J Sports Med 27:585, 1999
***p<0.10 compared to normal, 95%CI=0.9-6.7**
Same trends for achilles tendinitis, iliotibial band syndrome

Association of Genu Valgus and Genu Varus with Overuse Injury in Infantry OSUT



N=293 Men; Risk Ratio(Q1/Q5)=1.5

Cowan, Med Sci Sports Exerc 28:945, 1996 (Ft Benning, 1988)

Risk Factors for Injuries

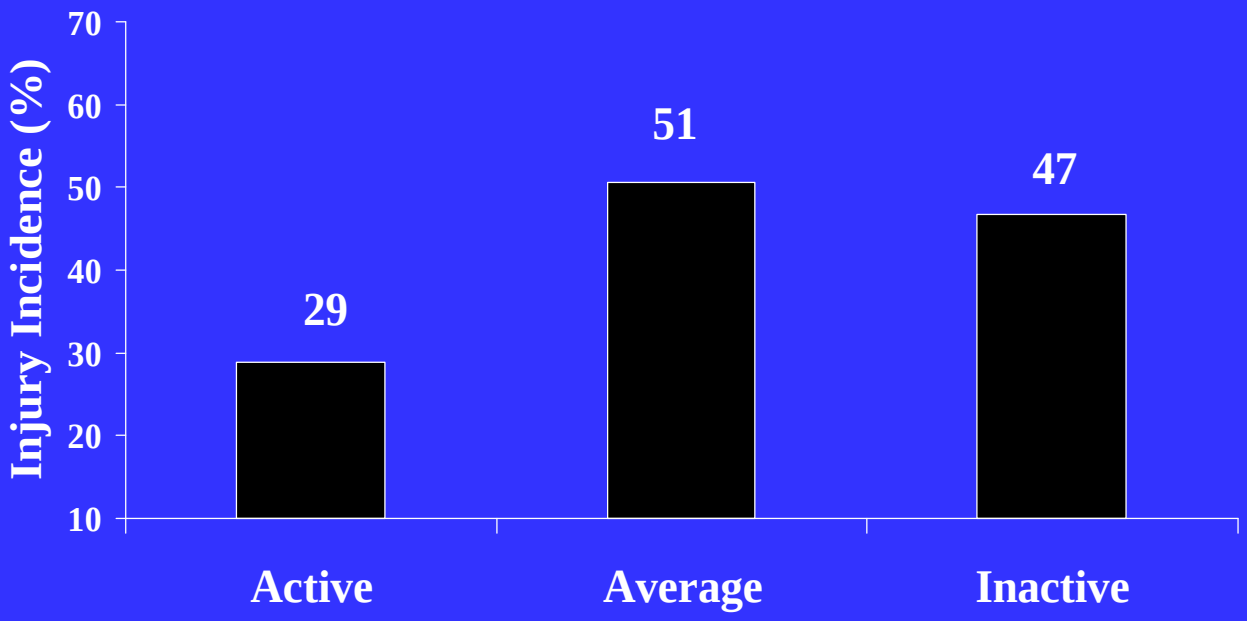
Nonmodifiable

- Female gender
- Older age
- Anatomy
  - Foot arch height
  - Knocked kneed

Modifiable

- Physical inactivity
- Low physical fitness
- High and low flexibility
- Cigarette smoking
- Long run mileage
- Old running shoes
- Summer season

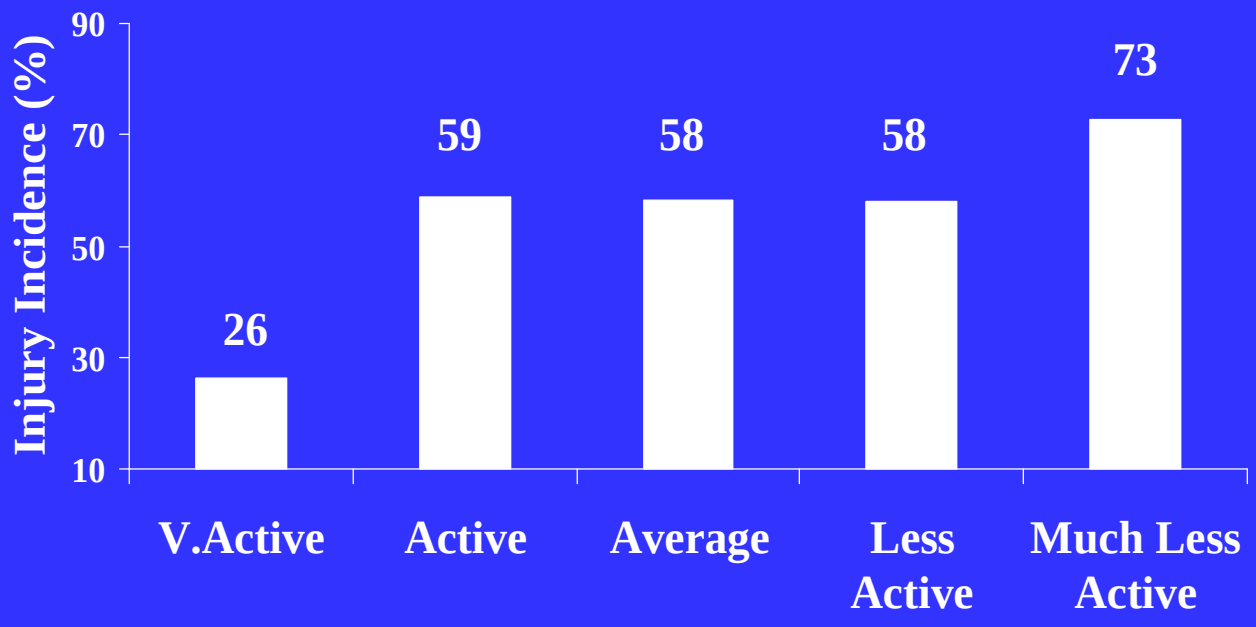
Association of Injuries and Self Assessed Physical Activity Level In OSUT (Men)



N=303 Men, Risk Ratio (Inactive/Active)=1.6, p<0.05 (Ft Benning, 1987)

Jones, Med Sci Sports Exerc 21:705, 1993

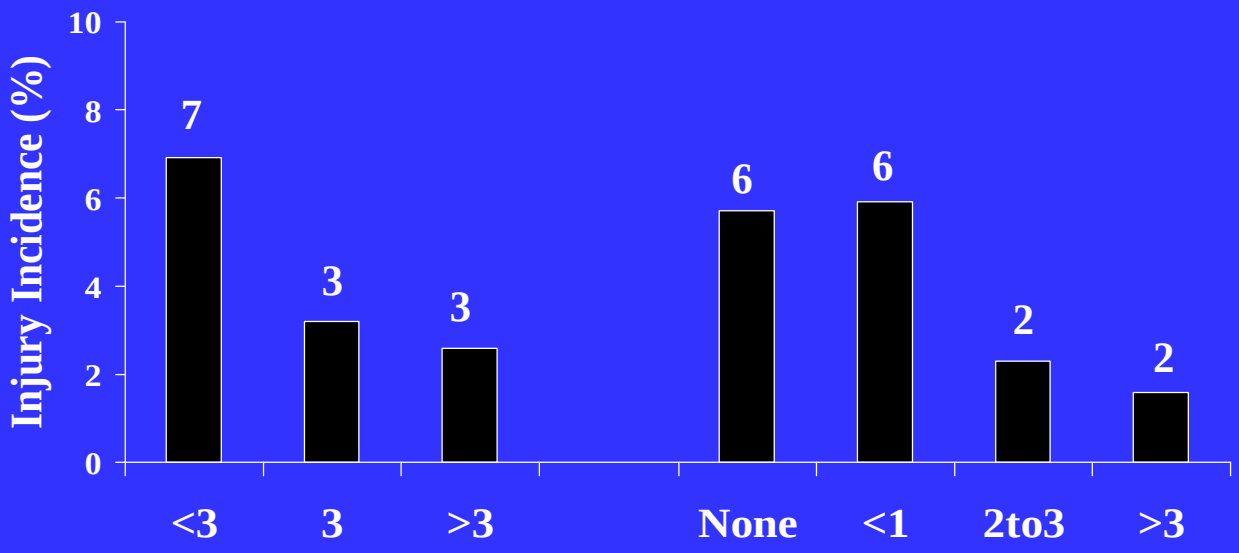
Association of Injuries and Self Assessed Physical Activity Level In BCT (Women)



N=185 Women, Risk Ratio (Much Less Active/V.Active)=2.8, p<0.01

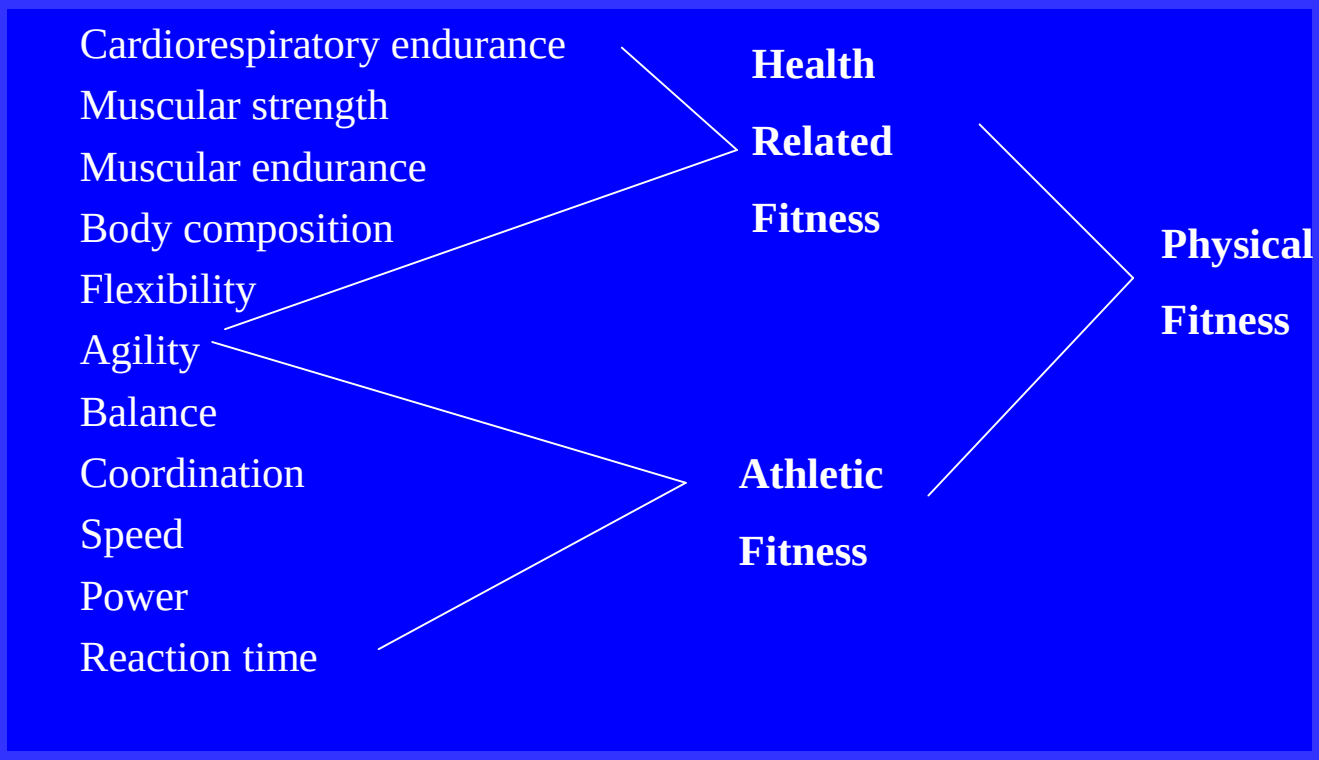
Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Association of Exercise History and Stress Fractures in Marine Recruits



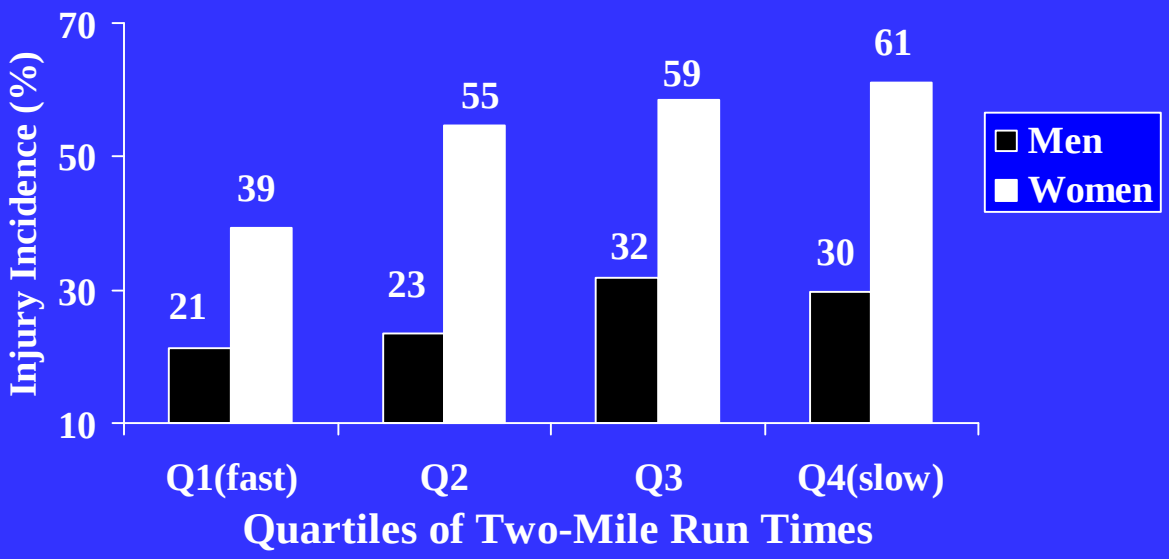
N=1286 Men (San Diego CA)
Shaffer, Am J Epidemiol 149:236, 1999

Components of Physical Fitness[a]



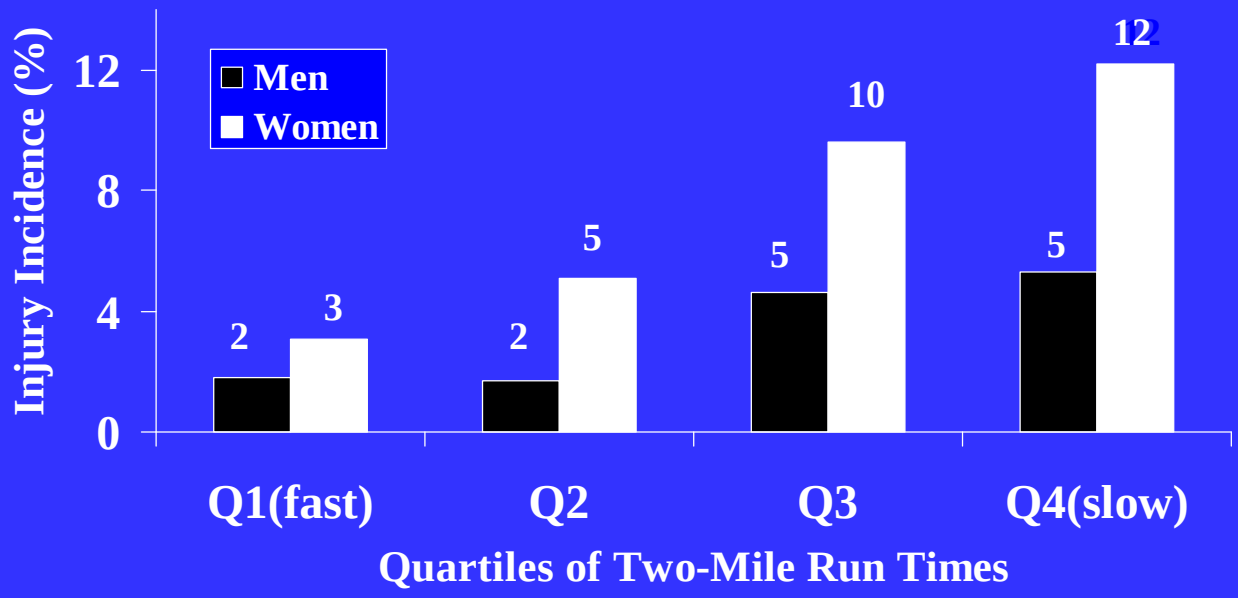
[a]From: Caspersen, Pub Health Rep 100:126, 1985

Association of First Two-Mile Run With Time-Loss Injuries in BCT



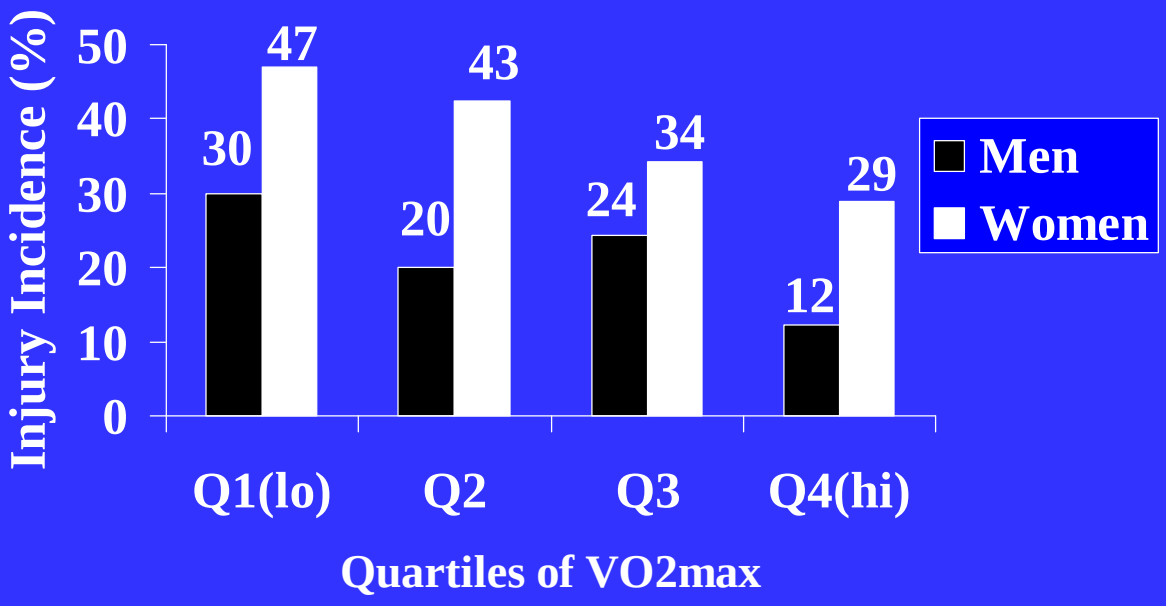
N=684 Men, 381 Women; Risk Ratio(Q4/Q1):Men=1.4,Women=1.6
p-value for Trend: Men=0.03, Women=<0.01
Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Association of Two-Mile Run and PTRP Injury in BCT



N=684 Men,386 Women; Risk Ratio(Q4/Q1):Men=2.9, Women=3.9
p-value (trend): Men<0.01, Women<0.01
Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Association of VO_2max with Injuries

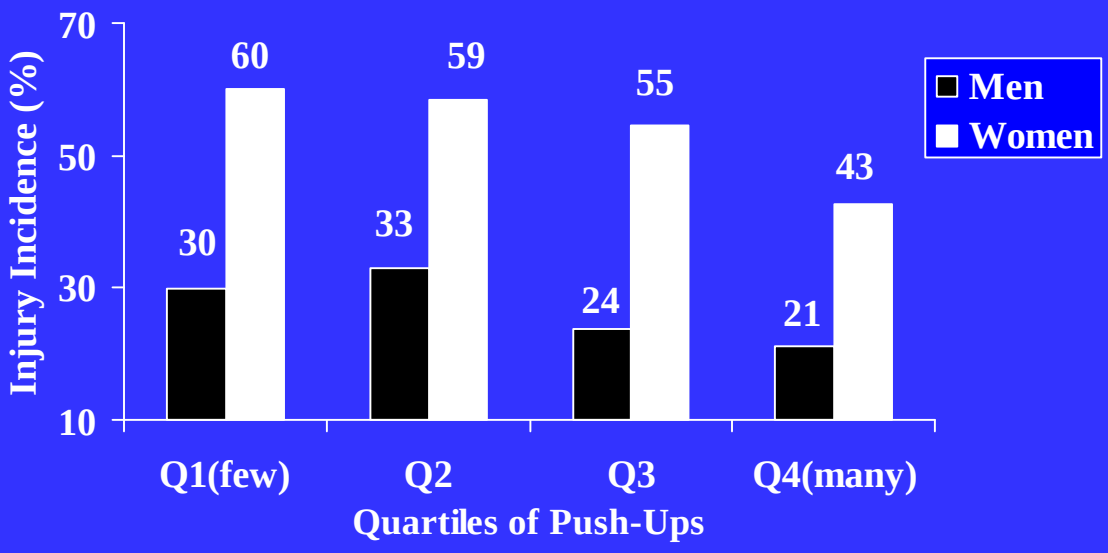


Risk Ratio(Q4/Q1):Men=2.5,Women=1.6
p-value for trend: Men=0.09, Women=0.09

Comparison of Individuals with High and Low Aerobic Capacity

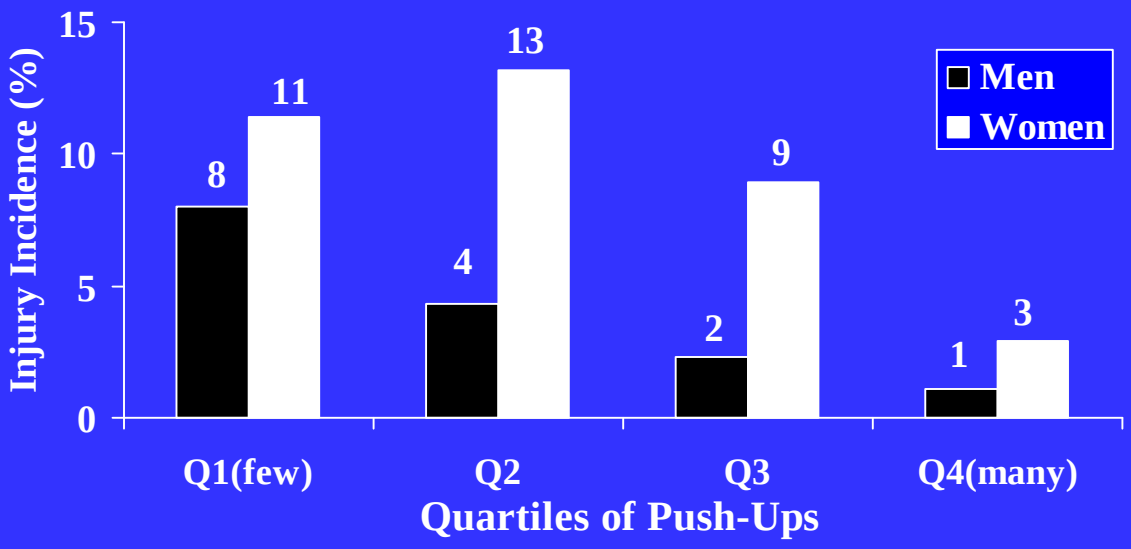
	VO_2max (ml/kg /min)	Road March Energy Use (ml/kg /min)	%VO_2max
High	50	20	40%
Low	40	20	50%

Association of First Diagnostic Push-Ups with Time-Loss Injury in BCT



N=692 Men,398 Women; Risk Ratio(Q1/Q4):Men=1.4, Women=1.4
p-value for Trend: Men=0.02, Women=0.01
Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Association of First Diagnostic Push-Ups with PTRP Injury in BCT



N=679 Men,398 Women; Risk Ratio(Q1/Q4):Men=7.3 Women=3.9
p-value (Trend): Men<0.01, Women=0.02 (Ft Jackson, 1998)
Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Key Steps in the Injury Control Process

- Surveillance (document problem and size)
- Research (identify cause and risk factors for injuries)
- Intervention (what works to prevent injuries and who needs to know)
- Program Implementation (action based on research and intervention trials)
- Program Monitoring (effectiveness of injury prevention strategy)

Possible Interventions for Risk Factors Physical Inactivity /Low Physical Fitness

- Emphasize youth activity/fitness and school physical education programs
- MEPS fitness test
- Pre-enlistment physical training
- Special PT once recruit acquired

Program Implementation

- Fitness Training Unit at Ft Jackson since 1985
- Attempt to increase trainee success in BCT by increasing fitness

Criteria to Enter and Exit the FTU (Ft Jackson, Summer 1998)

	Test Item	Men	Women
Entry	PU (reps)	<12	<3
	SU (reps)	<17	<17
	1-Mile Run (min)	>9:00	>11:00
Exit	PU (reps)	20+	6+
	SU (reps)	21+	21+
	1-Mile Run (min)	£9:00	£11:00

Program Monitoring

- Is the FTU effective?

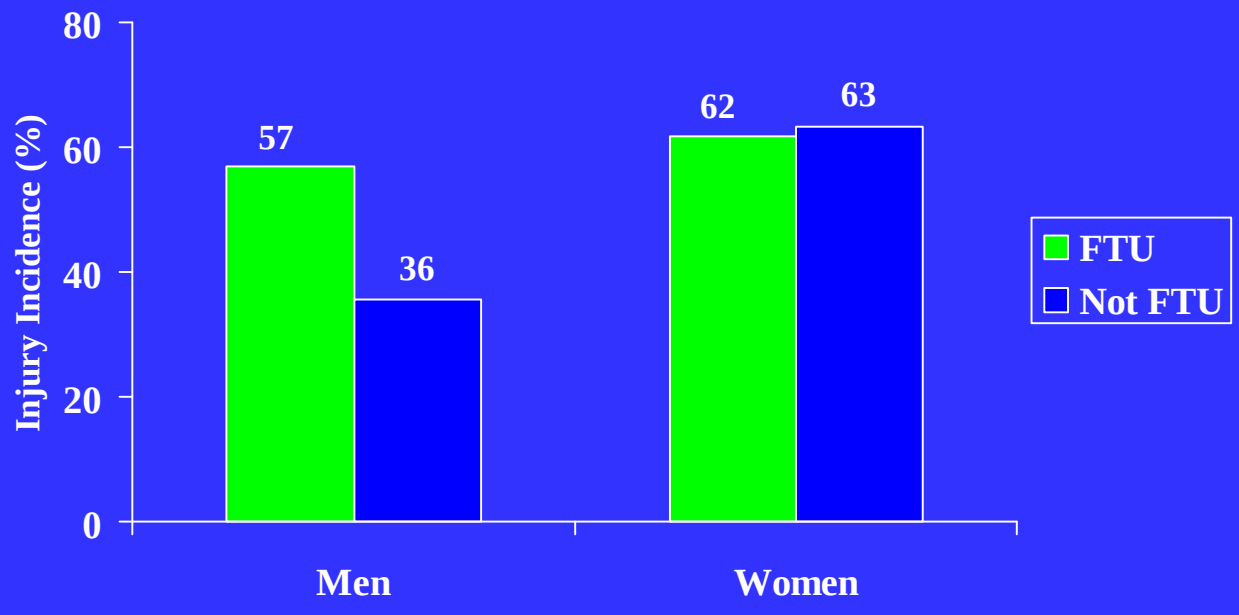
- Increase trainee success in BCT
  - Reduce injuries
  - Increase graduation rates

First Diagnostic APFT Results of FTU and Non-FTU Men and Women

		Men			Women		
		M	SD	p	M	SD	p
PU	FTU	23	13	<0.01	8	9	0.03
	Not FTU	33	14		11	10	
SU	FTU	38	16	0.24	30	15	<0.01
	Not FTU	41	13		36	15	
RUN	FTU	20.3	3.2	<0.01	21.6	2.7	0.86
	Not FTU	17.3	2.8		21.5	2.8	

Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

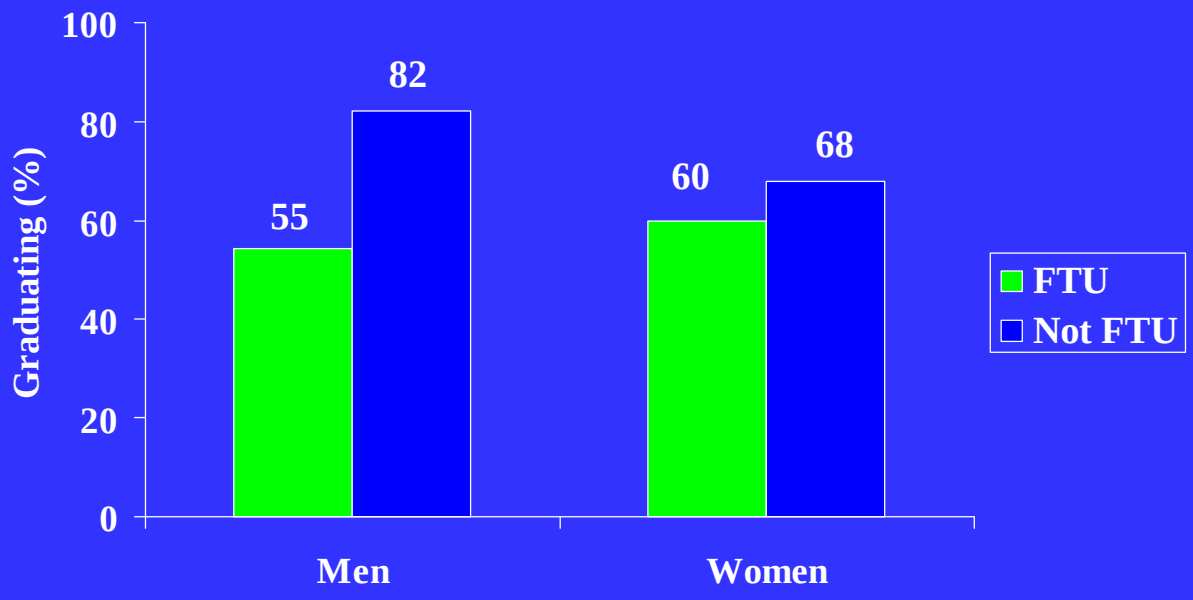
Comparison of Injury Incidence in FTU and Non-FTU Trainees



FTU Men=44,Women =89; Non FTU Men=689, Women=363
FTU vs Non FTU: Men p=0.01, Women p=0.78

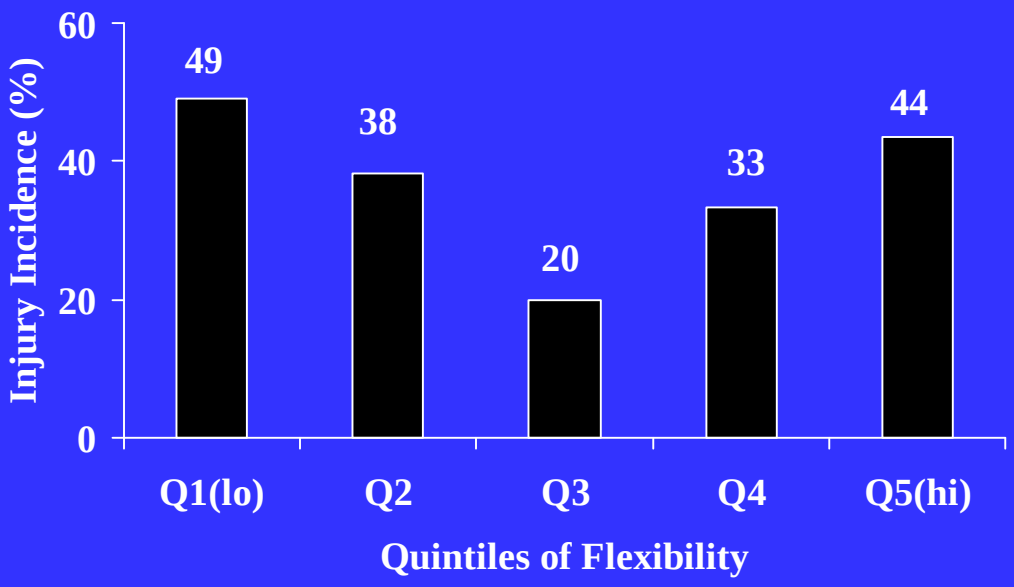
Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Comparison of FTU and Non-FTU Graduating (First Time) from BCT



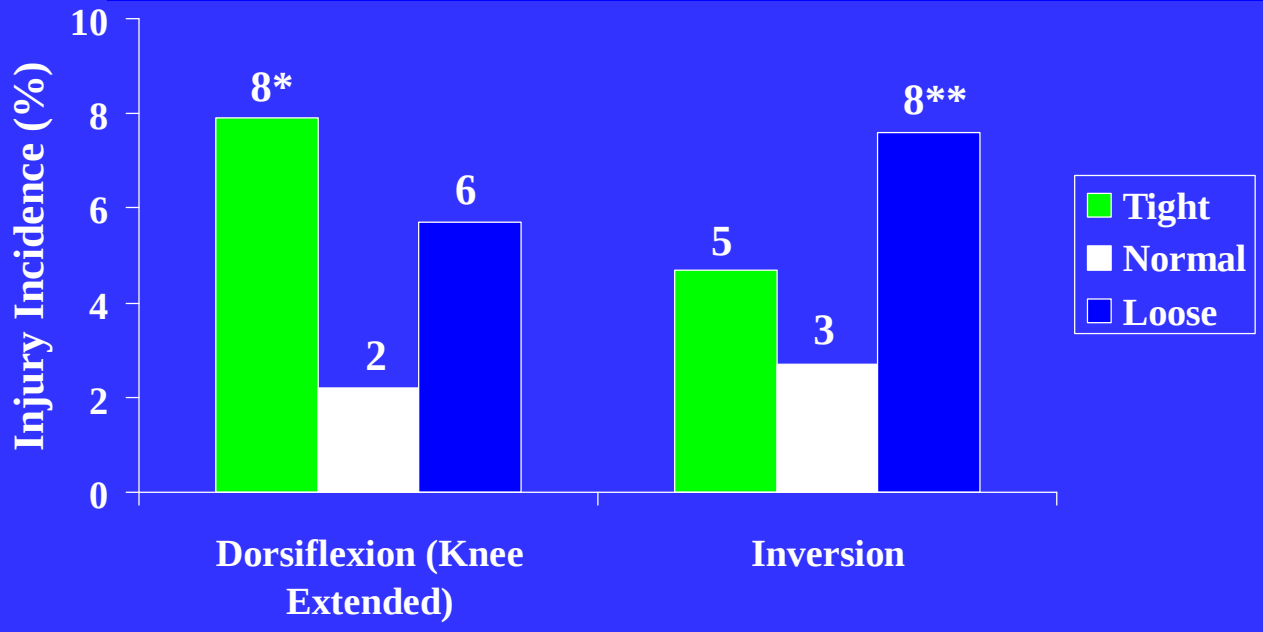
FTU Men=44,Women =86; Non FTU Men=712, Women=379
FTU vs Non FTU: Men $p<0.01$, Women $p=0.14$
Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Association of Flexibility with Lower Extremity Injury in Infantry OSUT



N=303 Men; Risk Ratio(Q1/Q3)=2.5, p<0.01
Jones, Med Sci Sports Exerc 25:197, 1993 (Ft Benning)

Association of Ankle Dorsiflexion and Inversion Flexibility with Achilles Tendinitis

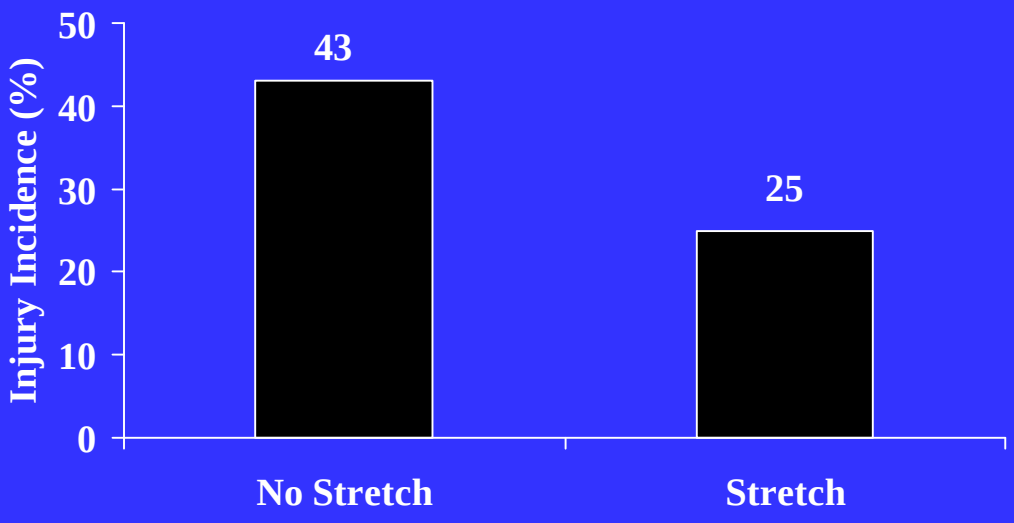


Kaufman, Am J Sports Med 27:585, 1999
***p<0.05 compared to Normal, 95%CI=1.0-12.7**
****p<0.10 compared to Normal, 95%CI=0.9-8.6**

Risk Factor - High/Low Flexibility

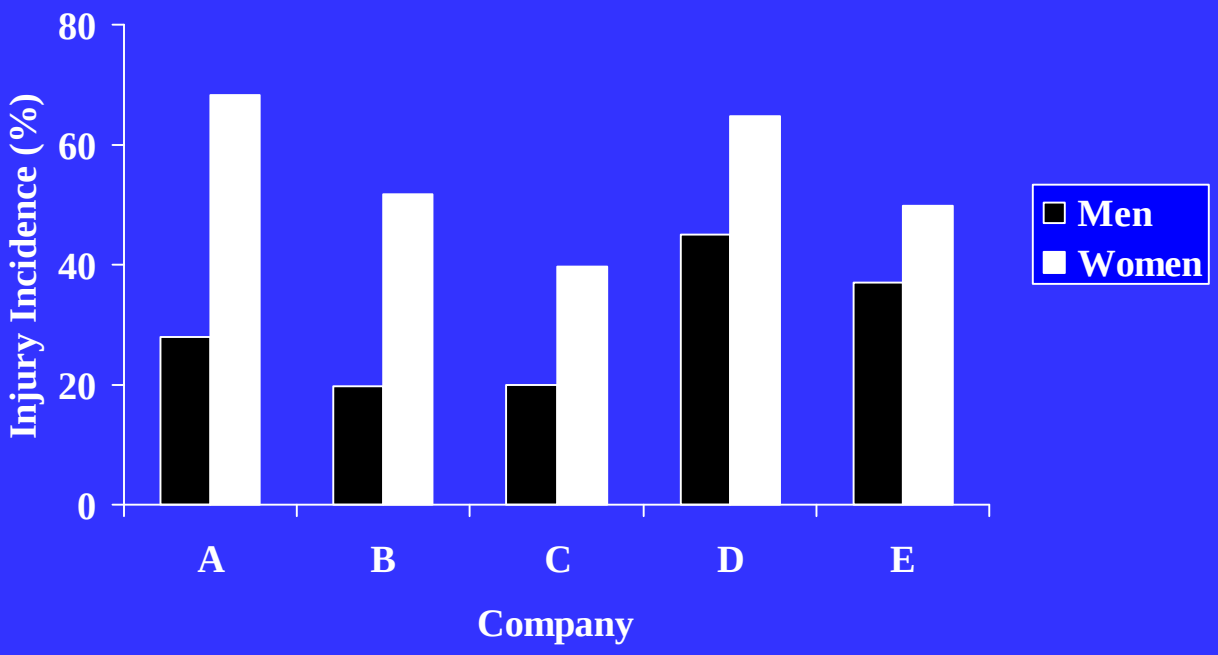
- Interventions
  - Stretching for less flexible trainees
  - Warm-up for less flexible trainees
- Program Implemented - Stretching prior to physical training for everyone
- Program Monitoring - Does stretching reduce injury?

Influence of Stretching on Lower Extremity Injury Incidence in Infantry Basic Trainees



p<0.02 Stretch Group vs No Stretch Group
N=150 Stretched Company, 148 No Stretch Company
Hartig, Am J Sports Med 27:173, 1999

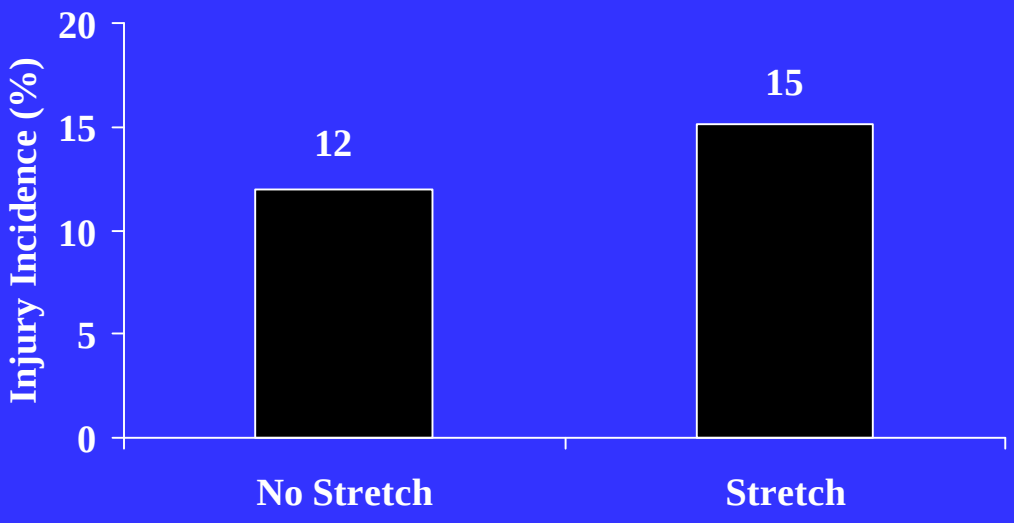
Injury Incidence in a BCT Battalion by Company (Ft Jackson, 1998)



N=344 Men, 241 Women

Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Influence of Stretching on Injury Incidence in Runners

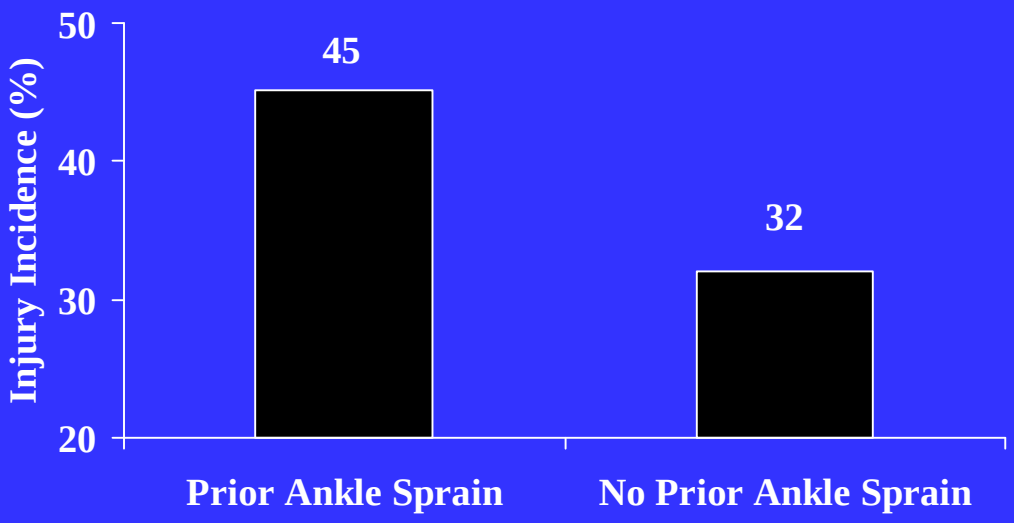


N=167 Stretched Group, 159 No Stretch Group; 16 week study
RR=1.3 (95%CI=0.7-2.3) p=0.41
Mechelen, Am J Sports Med 21:711, 1993

Flexibility as a Risk Factor

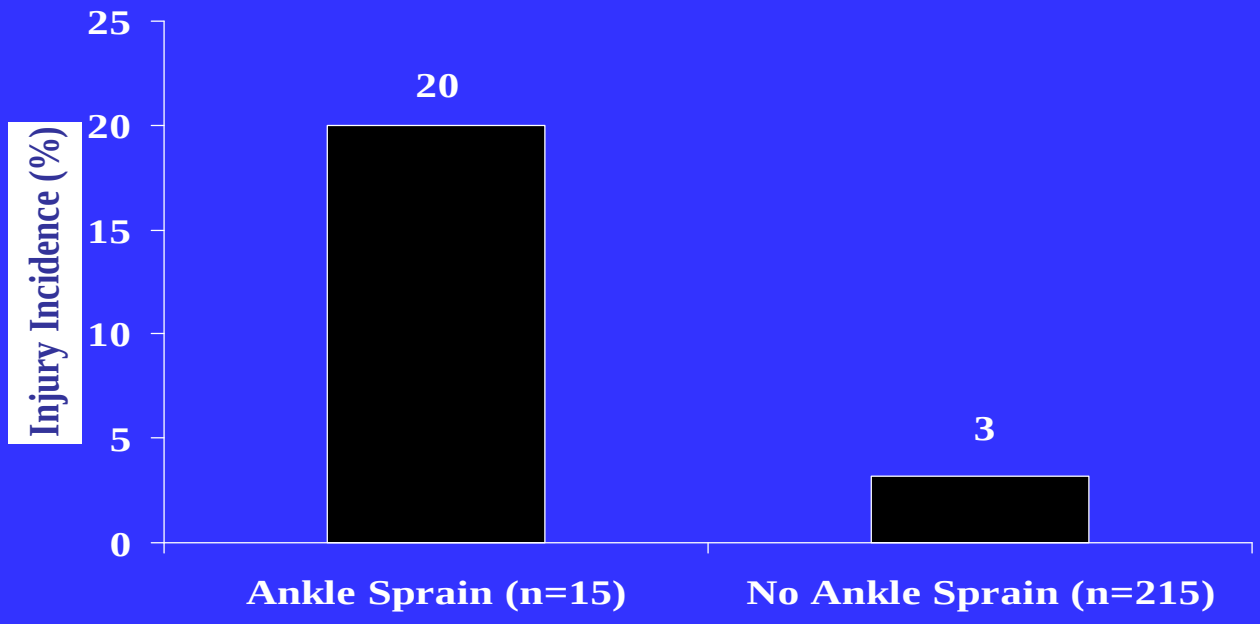
- Identify individuals with low flexibility
- Stretching for individuals with low flexibility
- Individuals with high flexibility?

Association of Prior Ankle Sprains and Injuries in Infantry OSUT



N=303 Men
RR=1.4 (95%CI=1.0-1.8), p=0.05
Jones, Med Sci Sports Exerc 25:197, 1993

Ankle Sprains in the Five Years Prior to the AWC and Sprains at the AWC



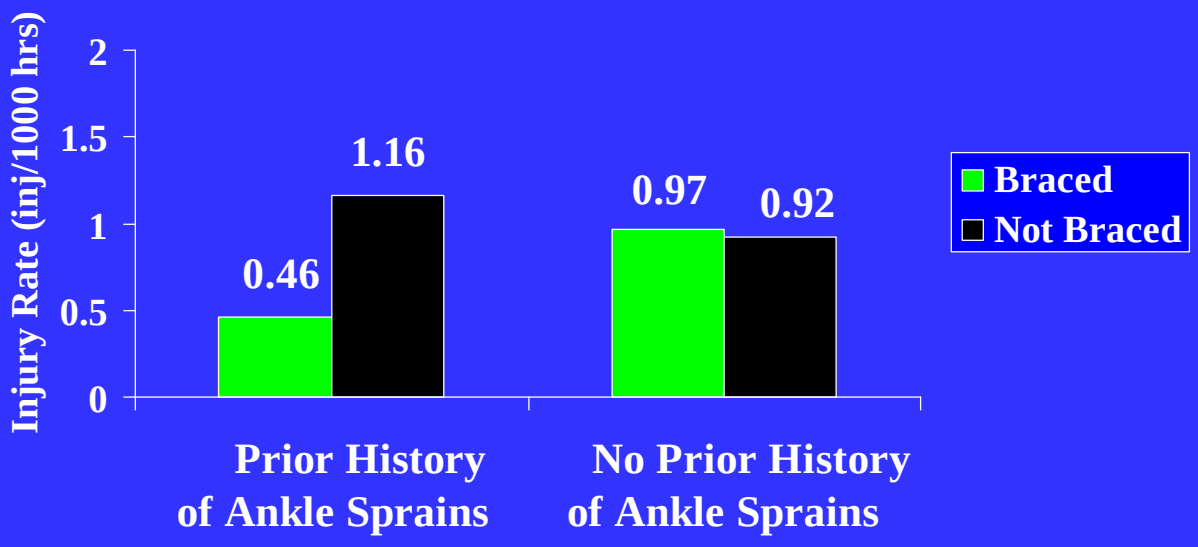
N=230 Senior Military Officers
RR=6.1 (95%CI=1.8-21.4), p<0.01
Knapik, USACHPPM Epicon Report No 29-HE-2682-99, 1999

Risk Factor - Prior Ankle Sprain

- Intervention - Brace the ankle (ankle sprains account for 8% of male and 6% of female injuries in BCT*)
- Implementation - Ankle braces for in soccer and basketball players
- Monitoring - Do ankle braces reduce ankle sprains?

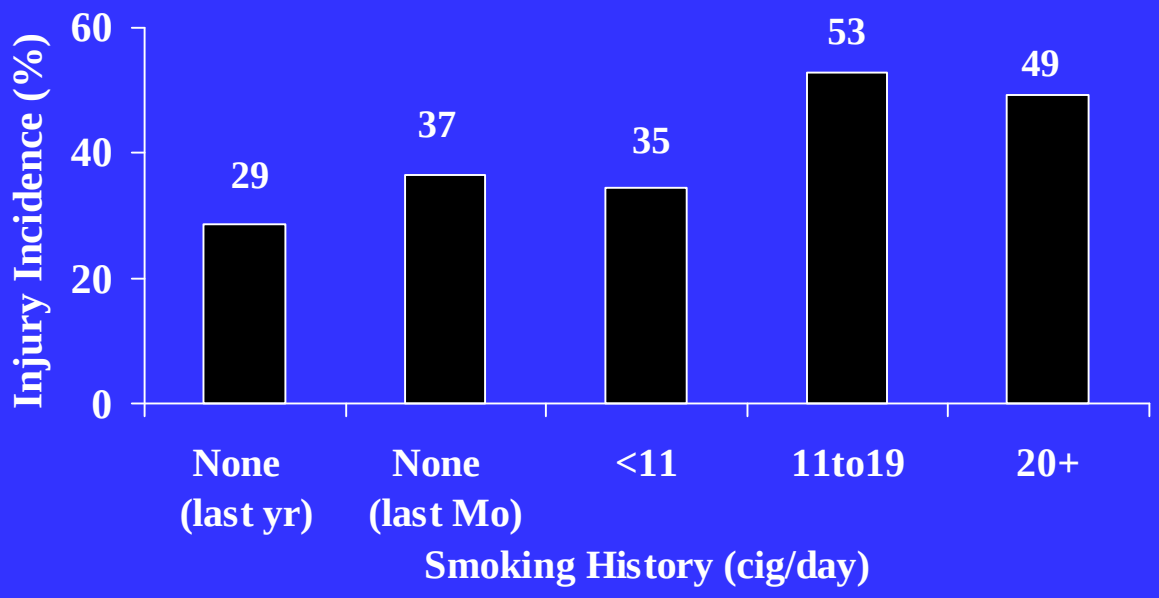
***Knapik Unpublished data, Ft Jackson SC, Summer, 1998.**

Influence of Ankle Braces on Ankle Sprains in Male Soccer Players



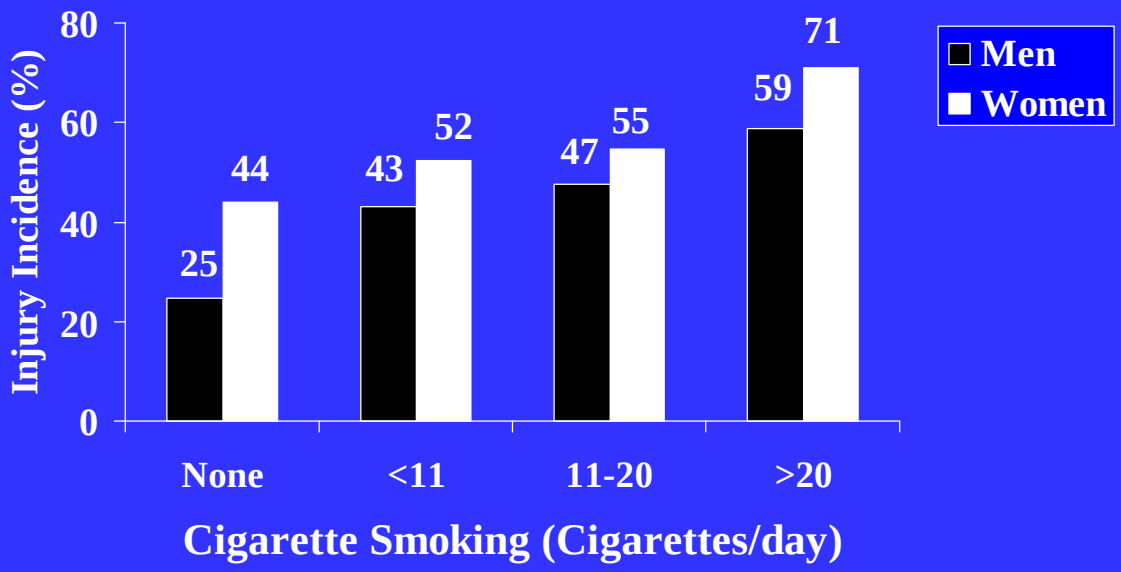
N=258 men with prior history, N=371 men with no prior history
Prior history RR=2.5, $p<0.01$; No prior history RR=1.0, $p>0.10$
Surve, Am J Sports Med 22:601, 1994

Association of Cigarette Smoking with Lower Extremity Injury in Infantry OSUT



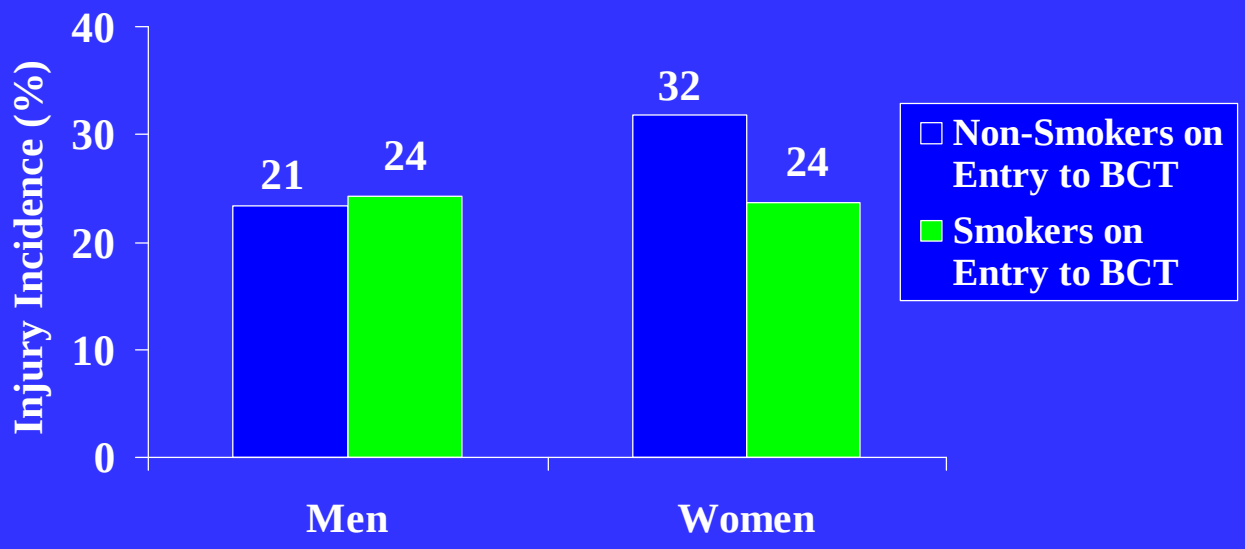
N=299 Men; Risk Ratio(20+/None in last yr)=1.7, p<0.01
Jones, Med Sci Sports Exerc 25:197, 1993 (Ft Benning)

Association of Cigarette Smoking with Time-Loss Injury (Ft Jackson, 1998)



N=225 Men,186 Women; Risk Ratio(>20/None):Men=2.4, Women=1.6
p-value: Men=<0.01, Women=0.01
Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Influence of Prior Smoking on Injury Incidence in Medic AIT

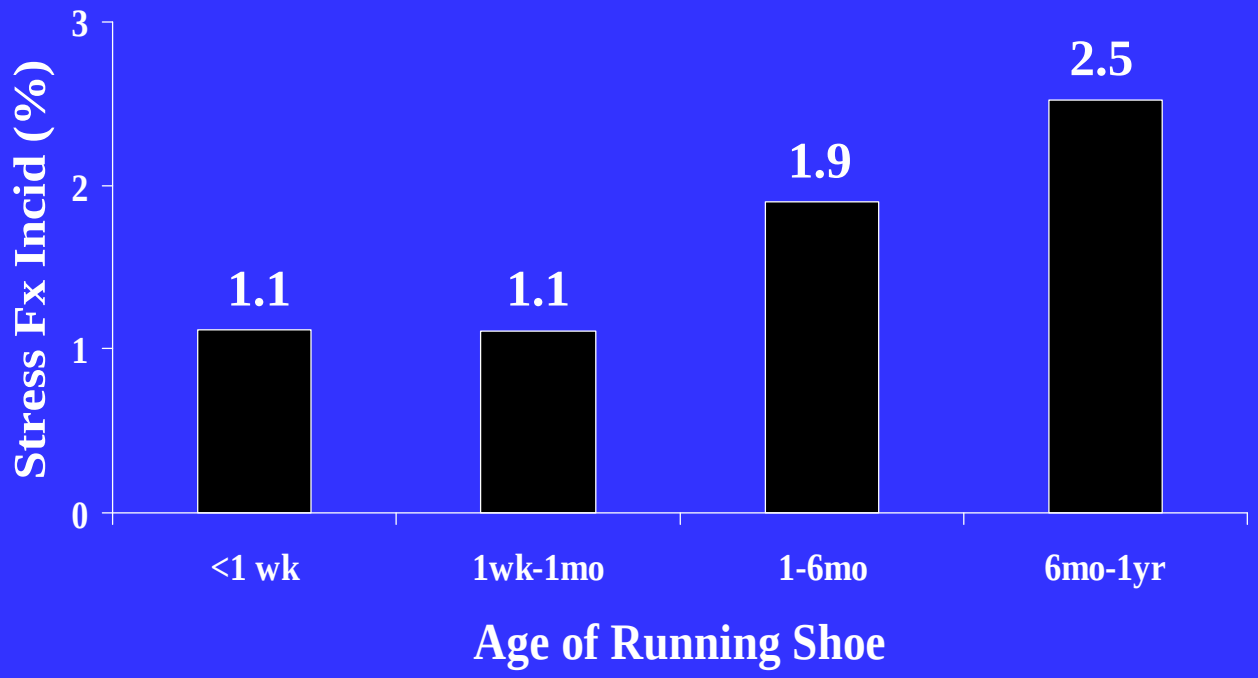


Men p=0.76; Women p=0.19
Henderson, Milit Med, In Press

Risk Factor: Cigarette Smoking

- Intervention
  - Discourage cigarette smoking in youth
  - Continue to prohibit smoking in BCT
- Program Implementation
- Program Monitoring
  - Prior smokers have higher injury incidence in BCT
  - Smoking cessation may have longer term effects possibly reducing injuries in AIT

Stress Fracture Incidence by Age of Running Shoe



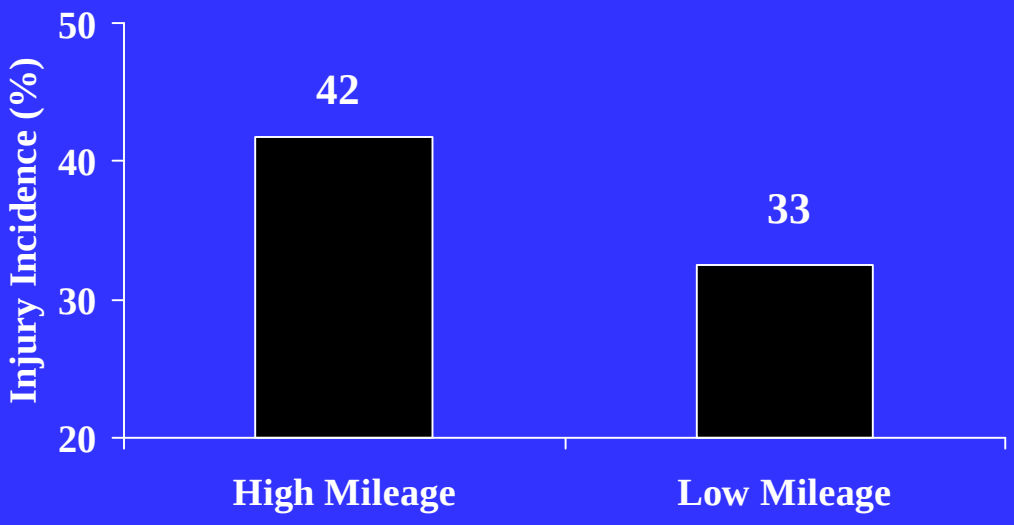
3007 Marine Recruits
p (for trend)=0.06

Gardner, Am J Pub Health 78:1563, 1988

Risk Factor: Older Running Shoes

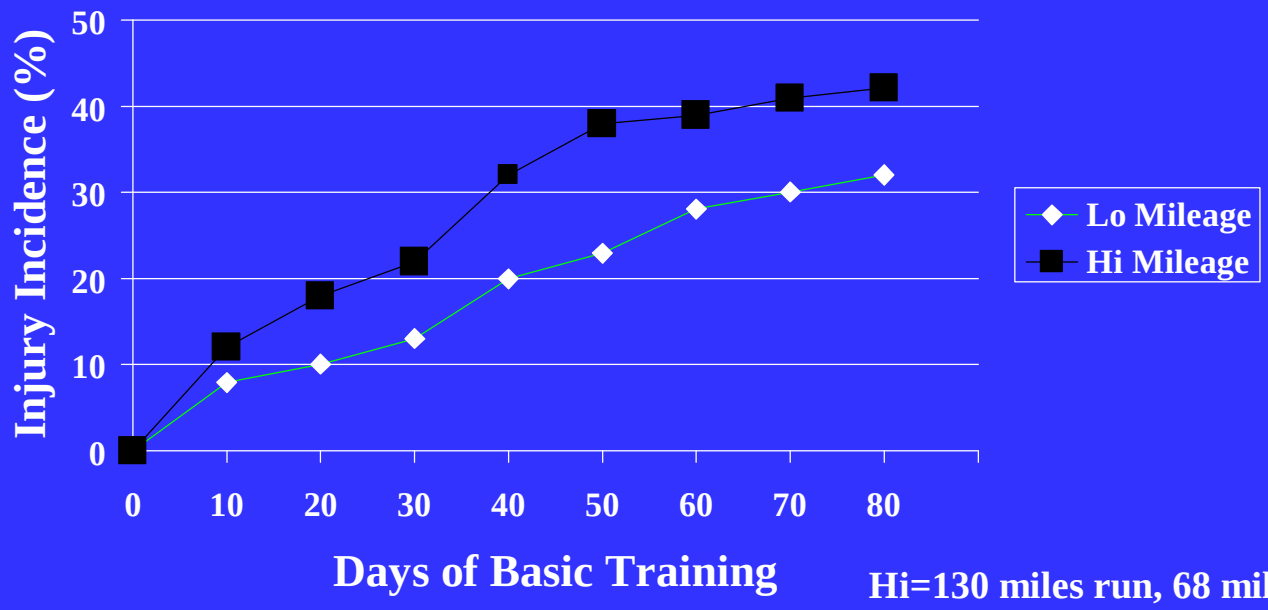
- Intervention - Put trainees in new running shoes
- Program Implemented - Each trainee buys new running shoe on entry to BCT (Ft Jackson 1998)
- Program Monitoring - Not monitored

Influence of Running Mileage on Lower Extremity Injury Incidence in Infantry Basic Trainees



High Mileage Group=130 miles/cycle; Low Mileage Group=56 miles/cycle
RR=1.3, 95%CI=1.0-1.7, p=0.09
Jones, Sports Med 18:202, 1994

Injury Incidence and Running Mileage in Infantry Basic Training

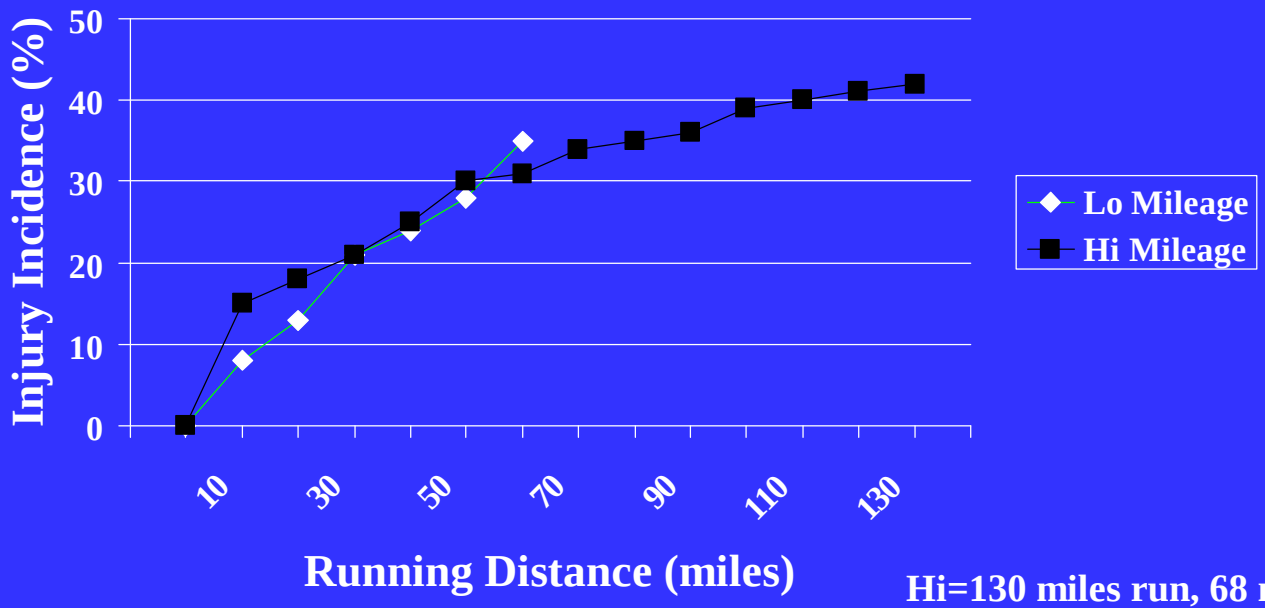


Hi=130 miles run, 68 miles marched, 198 miles total

Lo=56 miles run, 117 miles marched, 173 miles total

Jones, Sports Med 18:202, 1994

Injury Incidence in High and Low Mileage Infantry Basic Training Units



Hi=130 miles run, 68 miles marched, 198 miles total

Lo=56 miles run, 117 miles marched, 173 miles total

Jones, Sports Med 18:202, 1994

Effects of Running Mileage on Injury Incidence and Run Times in Infantry Basic Training

Mileage	*Injury Incidence*	*2 Mile Run Time**
Low	**33%**	**13:29**
High	**42%**	**13:45**

Jones, Sports Med 18:202, 1994
***Final APFT- Average Times**
Low Mileage = 56 miles/12 wks; High Mileage = 130 miles/12 wks

Risk Factor: Long Running Mileage

- Interventions

  - Reduce running mileage (how will this effect APFT run times?)

  - Substitute other types of aerobic training (how will this effect APFT run times?)

- Program Implemented and Monitored - Reduced running mileage (Navy/Marine Test)
- Program Implemented and Monitored - Substitute marching for running (Australian Recruit Study)

Navy Intervention Trial: Run Distance, Stress Fractures, and Fitness of Marine Recruits

Marines (N)	Run Distance (miles)	Stress Fx Incidence (n/100)	Final Three-Mile Time (min)
1136	55	3.7	20.3
1117	41	2.7	20.7
1097	33	1.7	20.9

Shaffer, Presentation at 43d Annual Meeting of the American College of Sports Medicine, Cincinnati, OH 1996

Risk Factor: Long Running Mileage

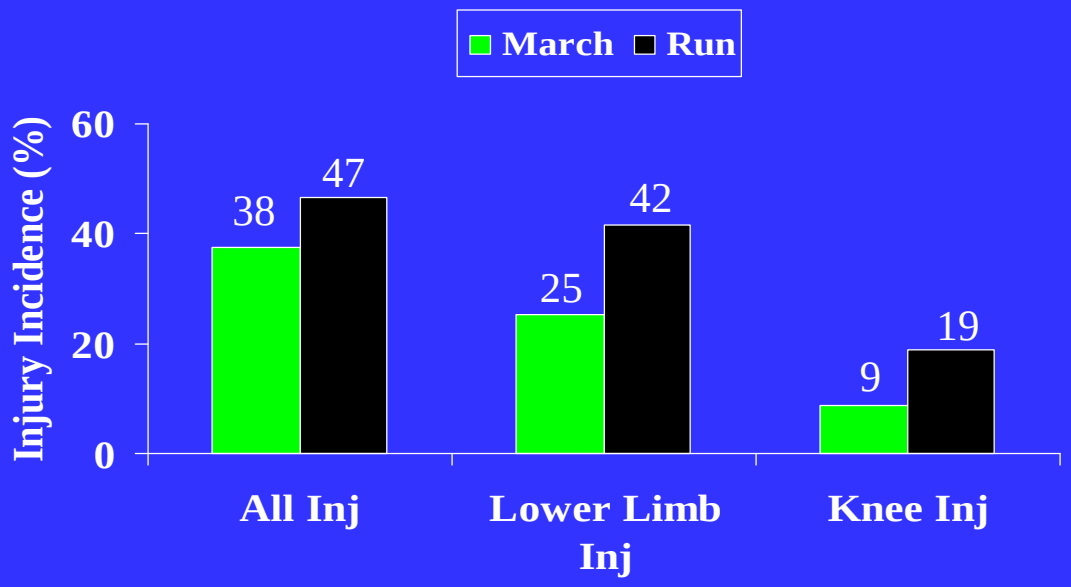
- Interventions

  - Reduce running mileage (how will this effect APFT run times?)

  - Substitute other types of aerobic training (how will this effect APFT run times?)

- Program Implemented and Monitored - Reduced running mileage (Navy/Marine Test)
- Program Implemented and Monitored - Substitute marching for running (Australian Recruit Study)

Effect of Substituting Marching for Running on Injuries in Australian Military Recruits



Rudzki, Milit Med 162:472, 1997

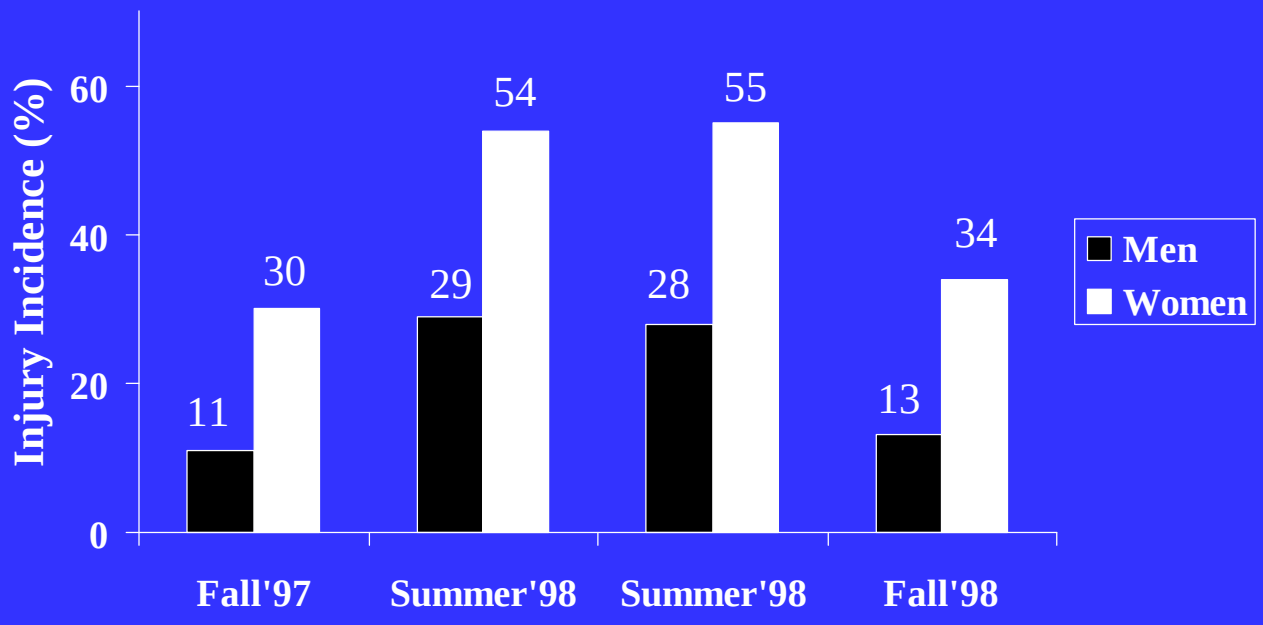
All Inj: RR=1.2, p=0.09 (95% CI=1.0-1.6)

Lower Limb Inj: RR=1.7, p<0.01 (95%CI=1.2-2.3)

Knee Inj: RR=2.1, p=0.01 (95%CI=1.2-3.8)

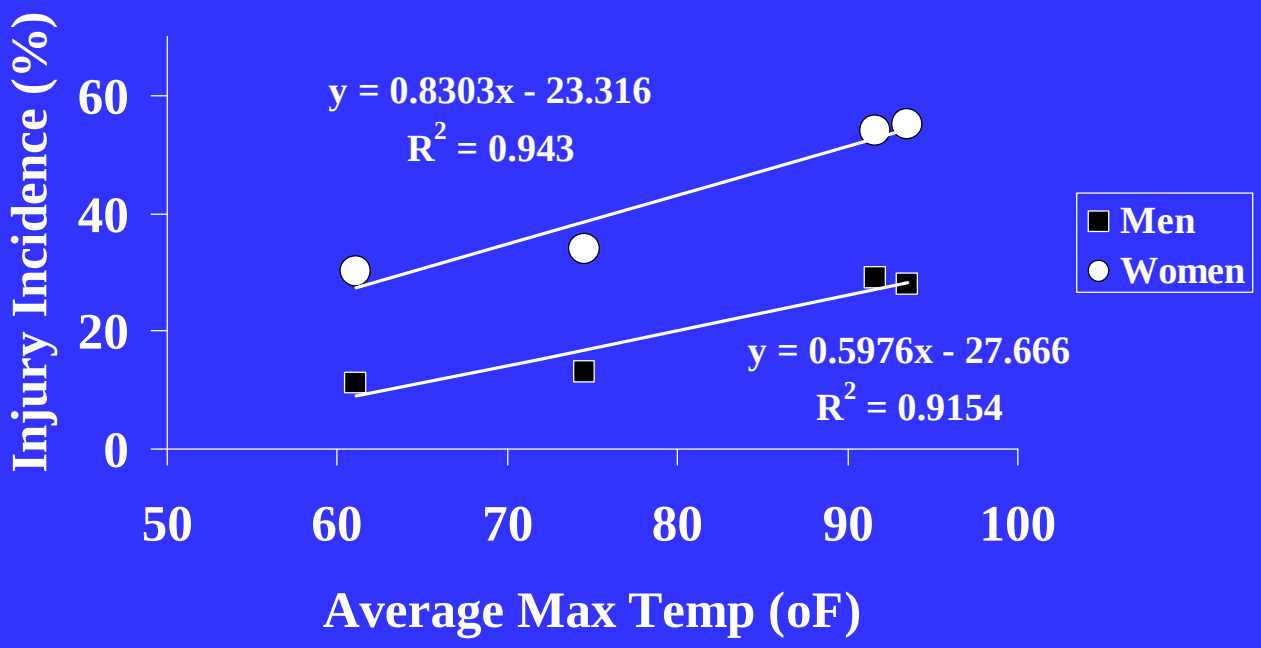
12 weeks training, 10-mile run reduction in March Group

Time-Loss Injury Incidence of Men and Women In Summer and Fall BCT Cycles (Ft Jackson 1997-1998)



Knapik, Med Surveil Monthly Report, In Press

Association of Temperature and Cumulative Incidence of Time-Loss Injuries

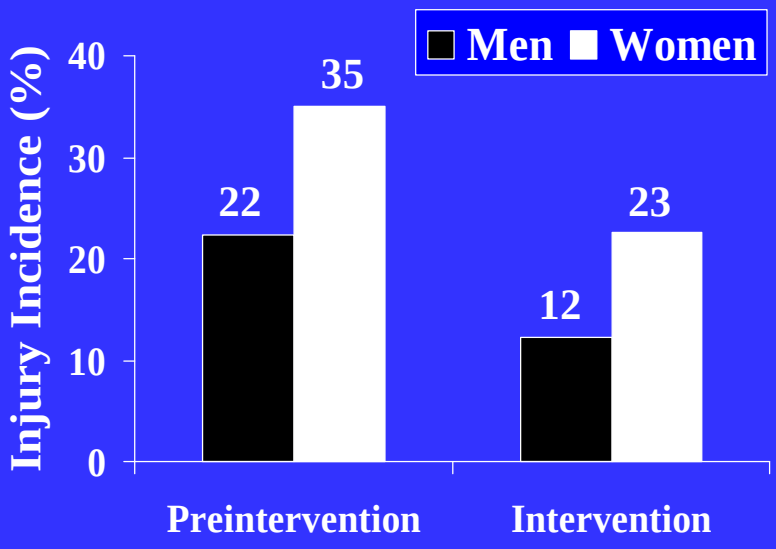


What Does Research on Risk Factors Tell Us?

- Trainee least likely to get injured- physically active, physically fit, non-smoking, young (<25 yr) man, with average flexibility, average foot arch height and average knee alignment (or bow-legged)
- Conditions least likely to result in injury- new running shoes, “low” run mileage, training in the fall (at Ft Jackson)

Australian Multiple Intervention Trail

Injury Incidence In Male and Female Australian Recruits After Multiple Interventions



Rudzki, Milit Med 164:649, 1999
Men: RR=1.8, p<0.01 (n=554&502)
Women: RR=1.5, p=0.06 (n=154&75)
Control: Jul95-Sep95
Intervention: Jan96-May96

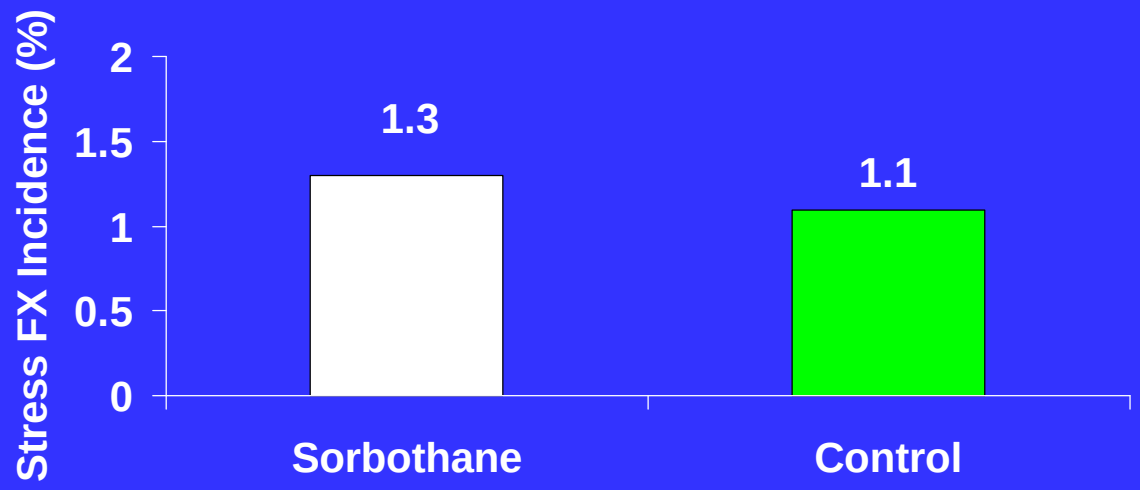
Interventions

1. **Interval runs (400-800m sprints) on grass for PT; reduced total distance (by 27 km); no group runs**
2. **Reduced march speed (to 6 km/h or 3.7 m/h); no running; gradual load increment**
3. **Deep water running on days after road marching**
4. **Reduced PT test run distance from 5 to 2.4 km**

Other Interventions Tested

- Insoles
- Cessation of running in third week of BCT
- Liner Socks (blisters)
- Antiperspirants (blisters)

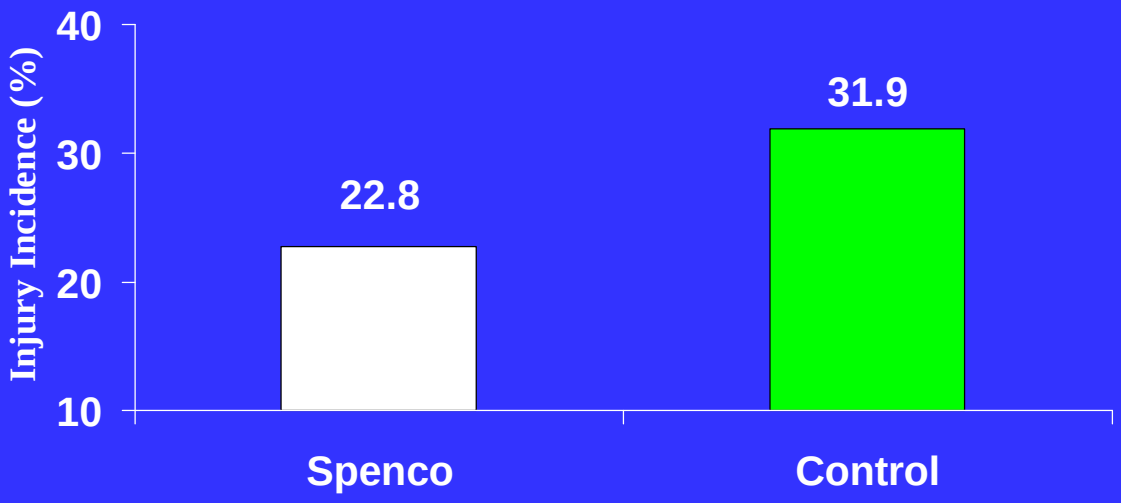
Stress Fractures By Insole Type Among Marine Recruits (Sorbothane)



Gardner, Am. J. Public Health, 78:1988

Parris Is. MCRD 1985
N = 3025 (1555 test, 1470 control)
Risk Ratio= 1.17, p = n.s.

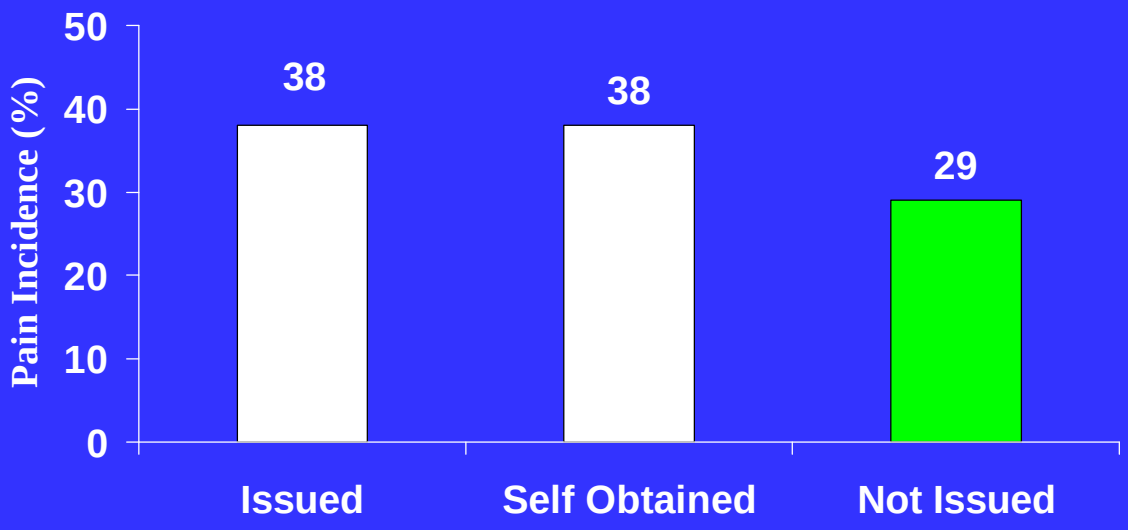
Injury Incidence in South African Recruits By Insole Type (Spenco)



Schwellnus, Am J Sports Med 18:636, 1990

N = 1388 (237 test, 1151 control)
Risk Ratio= 1.4; p<0.01

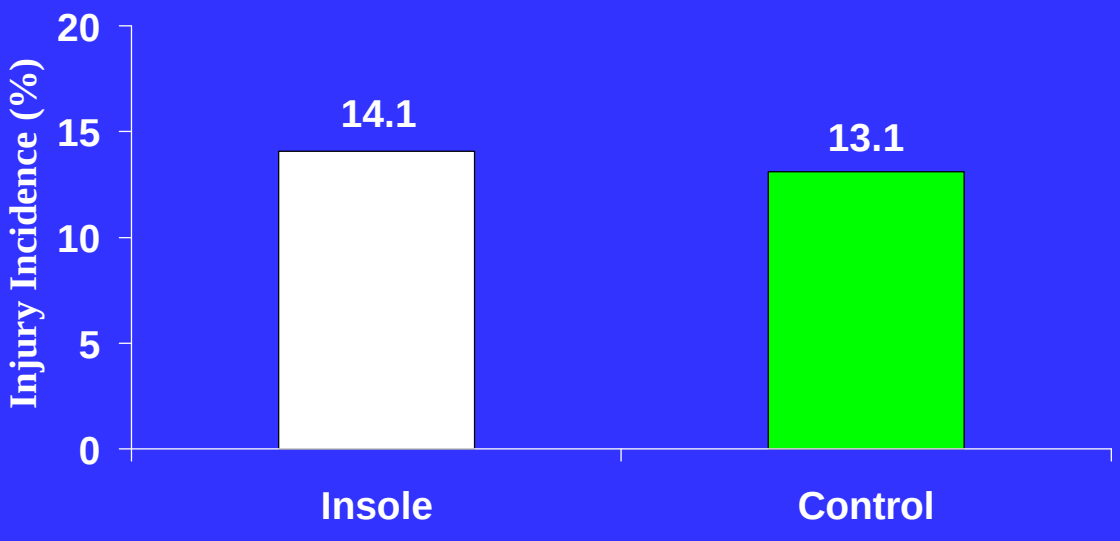
Lower Limb Pain in OSUT By Insole Type (Spenco)



Sherman, J Am Pod Med Ass 86:117, 1996
Chi Square p value=0.70

N = 517 issued
N= 218 self-obtained
N= 397 not issued

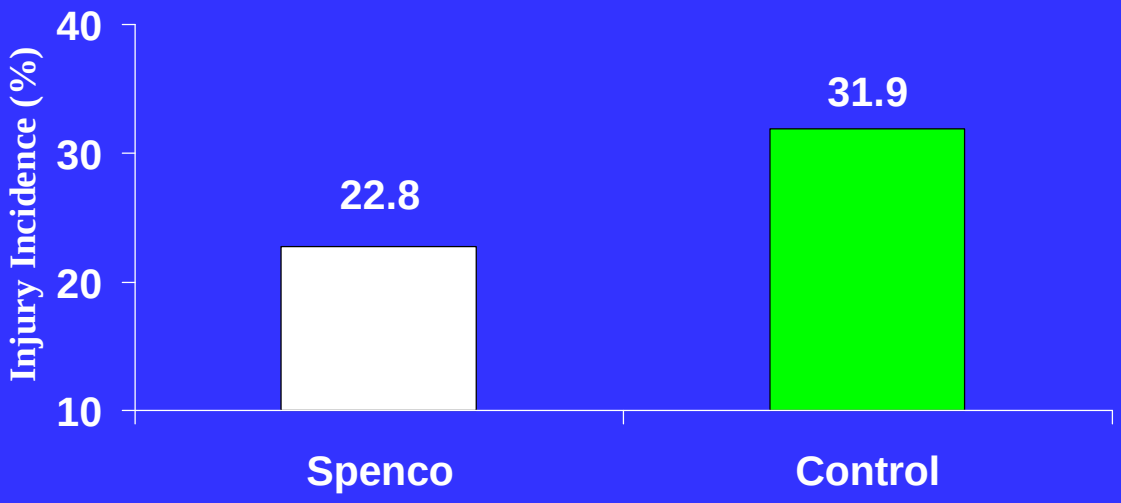
Lower Extremity Overuse Injury Incidence in Marine Corps Recruits By Insole Type



Maxwell, Med Sci Sports Exerc 30:S269, 1998

N = 1340 Marine Recruits
Risk Ratio= 1.1, p=0.60

Injury Incidence in South African Recruits By Insole Type (Spenco)



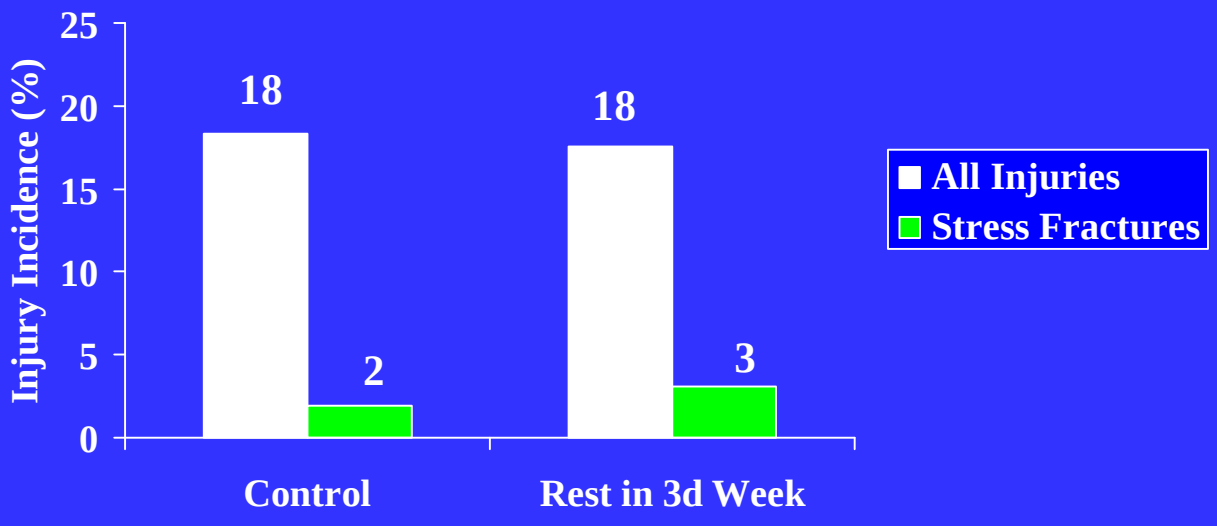
Schwellnus, Am J Sports Med 18:636, 1990

N = 1388 (237 test, 1151 control)
Risk Ratio= 1.4; p<0.01

Injury Rate by Week of Training (Ft Jackson, 1998)

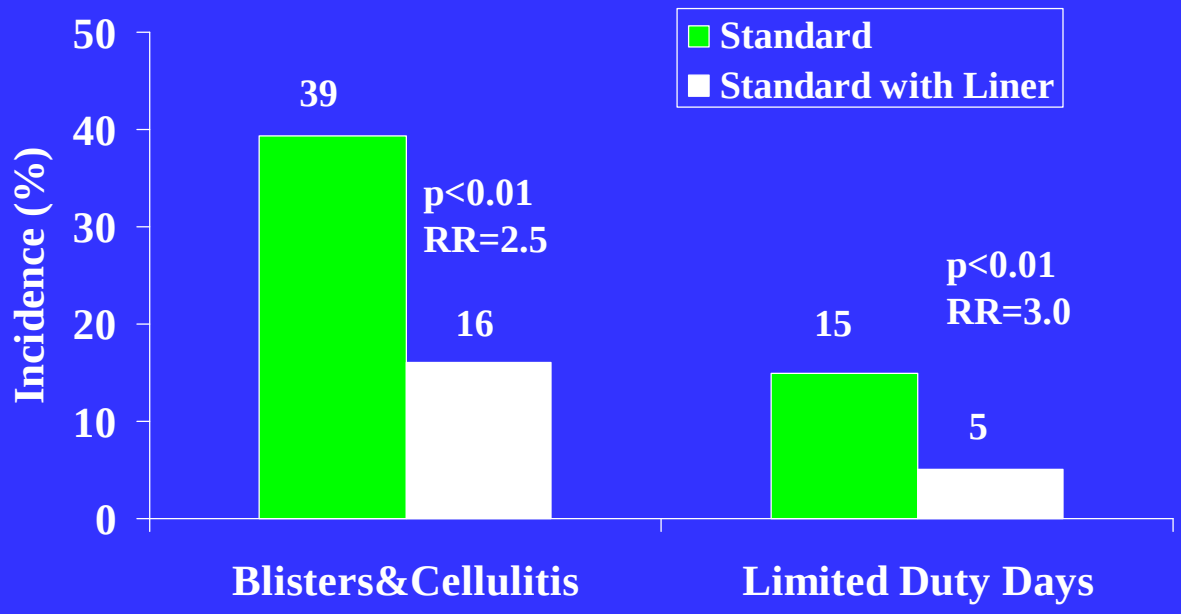
Knapik, USACHPPM Epicon Report No.29-HE-8370-98, 1999

Influence of Cessation of Running in Third Week on Injury Incidence in BCT (Ft Bliss, 1989)



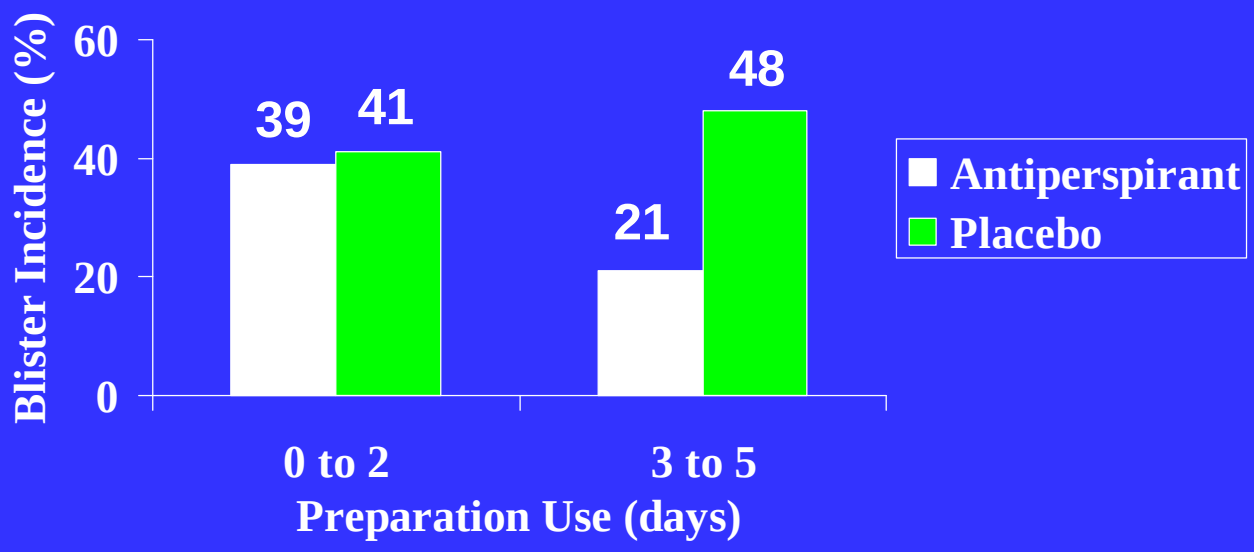
Control group ran 52 miles, marched 94 miles; final 2-mile run=14.3 min
Rest group ran 65 miles, marched 55 miles; final 2-mile run=14.4 min
Popovich, Am J Preventive Med, In Press

Effect of a Liner Sock on Foot Blisters and Cellulitis and Limited Duty Days During Marine Recruit Training



Standard Sock N=160, Liner Sock N=106; USMC Parris Island, SC
Knapik, Milit Med 161:594, 1996.

Influence of Antiperspirants on Foot Blisters During Road Marching



Knapik, J Am Acad Derm, 39:202, 1998

US Military Academy
21-km Road March
Risk Ratio (3-5days)=2.3, P<0.01

Effective Use of Antiperspirants to Reduce Blisters

- Use types with aluminum chloride hexahydrate that do not contain emollients
- Apply for 3-5 nights initially to build up antiperspirant effect
- Apply at least once a week thereafter to maintain antiperspirant effect

Key Steps in the Injury Control Process

- Surveillance (document problem and size)
- Research (identify cause and risk factors for injuries)
- Intervention (what works to prevent injuries and who needs to know)
- Program Implementation (action based on research and intervention trials)
- Program Monitoring (effectiveness of injury prevention strategy)

U.S. Army Center for Health Promotion & Preventive Medicine

Mission: Provide health promotion and preventive medicine leadership and services to counter environmental, occupational, and disease threats to health, fitness, and readiness in support of the National Military Strategy